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THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

VOL. 57 JUNE, 1947 No. 6

RADIUM THERAPY OF HEMANGIO-ENDOTHELIOMA OF THE UTERINE CERVIX*

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NEOPLASMS of the cervix uteri and vaginal walls usually are, first, primary carcinomas of the cervix uteri, although spread or metastasis to this site from other structures must be considered. The plan of radiation therapy often depends upon the primary site of the lesion, and the primary site also has a definite prognostic value. From our clinical experience, the second most common lesion involving the cervix or vaginal walls originates in the corpus uteri. Third, tumors that originate in the ovary may metastasize to the vaginal walls and cervix. Primary carcinoma of the urinary bladder or rectum may involve the same areas by direct extension. Primary carcinomas of the vaginal walls, although rare, may simulate a primary lesion of the cervix. Endometriosis may have to be distinguished from other conditions. Pedunculated fibroid tumors, with or without malignant degeneration, presenting in the cervix, as well as cervical polyps, endometrial polyps protruding from the cervix, tuberculosis, syphilitic lesions and leukoplakic lesions all may furnish problems in differentiation.

The history is an important factor in the determination of the diagnosis of cervical carcinoma. Pelvic examination and adequate visualization of the vaginal cavity, including the taking of tissue from the lesion for microscopic study, are most essential. The prognosis depends on the site of the primary lesion and on the extent of spread at the time of the presentation of the patient for diagnosis.

Primary malignant neoplasms of the uterine cervix consist chiefly of squamous cell epitheliomas, which have a dominant tendency toward higher grades of malignancy. It is entirely possible for other forms of neoplasm to exist, but they are extremely rare. A previous study at the Mayo Clinic[1] revealed that 59 per cent of malignant neoplasms of the cervix were epitheliomas, 3.5 per cent were adenocarcinomas, 36.9 per cent were unspecified carcinomas, 0.5 per cent were epitheliomas and adenocarcinomas, and 0.1 per cent were endotheliomas.

* Presented at the Twenty-eighth Annual Meeting, American Radium Society, San Francisco, Calif., June 28–29, 1946.

It is not likely that these percentages have changed much, excepting that the unspecified carcinomas may now be grouped with the epitheliomas.

The purpose of this paper is to report 4 cases in which hemangio-endothelioma occurred in the cervix uteri. MacCallum[4] says, "In practically no case has the origin of a tumor from endothelium been proved." But theoretically, tumors of endothelium can occur in any part of the body, since endothelium exists in or about all organs.

Hemangio-endotheliomas are rare, but have been reported in many organs in the body. To our knowledge, our cases constitute the first report of this tumor in the cervix. Ewing[3] referred to several early authors as reporting tumors of endothelial origin in the cervix, but concluded that the lesions reported most probably represented atypical forms of epithelioma. It is believed that endothelium receives, in its very earliest development, a contribution from both ectoderm and mesoderm.[5] During the early stages of development, however, the mesoderm has its anlage in the primitive embryonic ectoderm, extending laterally from the primitive streak and groove between the ectoderm and endoderm. Therefore, malignant cells of endothelial origin in their despecialization may exhibit morphologic characteristics of both epithelial tissue and mesodermal tissue.

REPORT OF CASES

CASE 1. An unmarried woman, aged forty-three, was referred to the clinic on June 16, 1922, because of a malignant process of the cervix. She complained chiefly of loss of strength that had developed during the four or five months previous to her visit, of weakness, constipation, swelling of the ankles and a slight vaginal discharge which had been blood-tinged at times.

She stated that her trouble had begun about four months before she came to the clinic, when she had begun to tire easily and to become constipated. She would become short of breath easily, and would tire in walking to the school in which she taught and in doing her usual duties. She would have to strain to produce a bowel movement. She had noticed blood in the stool. Thereafter, she took mineral oil and obtained some relief. In the four or five months prior to her registration at the clinic she had lost about 15 pounds (6.8 kg.).

She did not seem greatly concerned about her pelvic symptoms, possibly because she thought they might be the natural accompaniments of her age, but stated that about a year and a half prior to her visit her periods became very numerous; then had been absent for four months. They then returned as before, but, five months before her admission to the clinic, the flow had become quite scanty. For a few months prior to her visit a vaginal discharge had been present which at times had contained streaks of blood.

The menstrual history of this patient was normal. Menstruation had begun when she was fourteen years of age. Menstruation had been regular, with periods occurring every twenty-eight days and lasting four to five days. The flow was rather scanty, attended by some degree of dysmenorrhea.

The familial history was not definite; the patient's father had died of old age but was thought to have had a cancer of the liver.

Physical examination revealed that her normal weight would be 120 pounds (54.4 kg.). When she was admitted her weight was 100 pounds (45.4 kg.). Blood pressure was 140 systolic and 70 diastolic, expressed in millimeters of mercury. The pulse rate was 88 per minute and the oral temperature, 100.2° F. (37.8° C.). The thyroid gland was enlarged to grade 2; an adenoma was felt in the left lobe. The heart was enlarged, with the point of maximal impulse occurring 10 cm. to the left of the midsternal line. A loud systolic murmur was heard at the apex cordis, along the left border of the sternum and toward the left axilla. A small tender mass, the size of a plum, was felt in the left iliac fossa.

Pelvic examination revealed a large irregular, hard, necrotic, bleeding mass which almost filled the vagina and infiltrated all of the vaginal walls. Rectal examination revealed infiltration of stage IV, plus into the broad ligaments, with more on the left than on the right, and large, painful, bleeding hemorrhoids.

Laboratory examination showed the value for hemoglobin to be 3.3 gm. per 100 cc. of blood. Leukocytes numbered 5,800 per cubic millimeter of blood. The urine was normal.

A clinical diagnosis of carcinoma of the cervix, stage IV, was made. A specimen of tissue

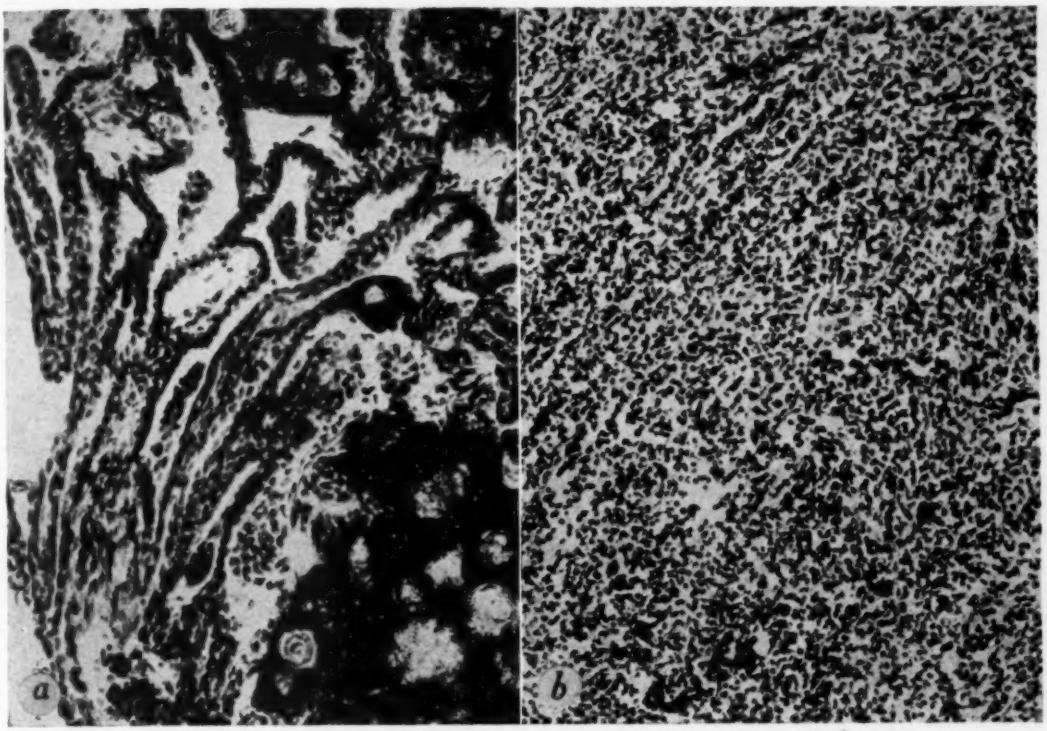

Fig. 1. *a*, Case I, hemangio-endothelioma, grade 1, showing the formation of vessels and also a number of psammoma bodies (hematoxylin and eosin ×160); *b*, Case II, hemangio-endothelioma, grade 2, showing the formation of numerous small vessels (hematoxylin and eosin ×125).

for microscopic examination taken from the mass revealed a hemangio-endothelioma with numerous psammoma bodies (Fig. 1*a*).

Because of the extent of this patient's lesion and her physical condition, only limited treatment with radium and roentgen rays was administered, but she did obtain remarkable palliation. Two months after treatment at the clinic she received additional radium treatment elsewhere; at the same time, a rectovaginal fistula was discovered. She did not have much discomfort from the fistula and it was not repaired. She received additional radiation therapy in 1925 and 1926, and from time to time was reported to be in good health, with no discomfort. In November, 1929, her feet began to swell and her family reported that she "seemed to fill with water." She died in December, 1929, at home, at the age of fifty-one, having survived the process in question seven and a half years. Death may have been caused by long-standing heart disease.

Case II. A quadriparous married woman, aged fifty-nine, came to the clinic in January, 1938, because of vague pains across the lower part of the abdomen. The pains had started about a month before. She had seen her local physician, who told her she had a pelvic tumor and advised an operation. She had then consulted another physician, who advised irradiation. After that, she had come to the clinic for decision. Eight months before, in another city, she had undergone rectal examination, because of rectal soreness. A rectal fissure had been found, but evidence of a pelvic tumor apparently was not encountered. She had not noted vaginal bleeding since the occurrence of the menopause eight years previously.

The patient had undergone amputation of the left breast two years prior to her registration. She had received two courses of ten roentgen-ray treatments for a cancer of the breast. Her father had died of cancer of the rectum.

Physical examination revealed a surgical scar resulting from radical mastectomy and a large, hard, nodular mass filling the entire pelvis and extending to about three fingers below the umbilicus. The mass was movable and thought to be multiple fibromyomas. In the upper part of

the vagina there was a mass which seemed to replace the cervix. Tissue taken from this mass proved to be hemangio-endothelioma of grade 2 (Fig. 1*b*).

Roentgenologic examination of the thorax revealed a lesion in the left apex pulmonis. This lesion was very difficult to evaluate, in view of the history of the carcinoma of the breast two years previously, and in view of the fact that tuberculosis could not definitely be ruled out.

Treatment consisted of high voltage roentgen rays directed to four pelvic and four thoracic fields. At re-examination three months later it was found that the patient had greatly improved. She had no abdominal pains. The pelvic mass was much smaller than at the first examination and was ill-defined. Roentgenologic examination of the thorax disclosed considerable resolution of the lesion previously noted.

Treatment at this time consisted of high voltage roentgen rays directed to six pelvic fields and four thoracic fields. The patient was seen no more at the clinic. Her son later reported that she had died three months after her last visit to the clinic. The details of her death are not known. She lived approximately six months after she had first been seen at the clinic.

CASE III. A quadriparous married woman, aged sixty-two, came to the clinic in November, 1941, because of spotting with blood from the vagina. Her sister had died of a uterine cancer, and she, of course, was very greatly concerned by the possibility that she also might have cancer. She had been seen at the clinic three years previously; at that time no pelvic pathologic process had been demonstrated. Her only symptoms were occasional spotting with blood from the vagina.

The results of general physical examination were normal, except for the pelvis, which contained a white, irregular polyp extending to

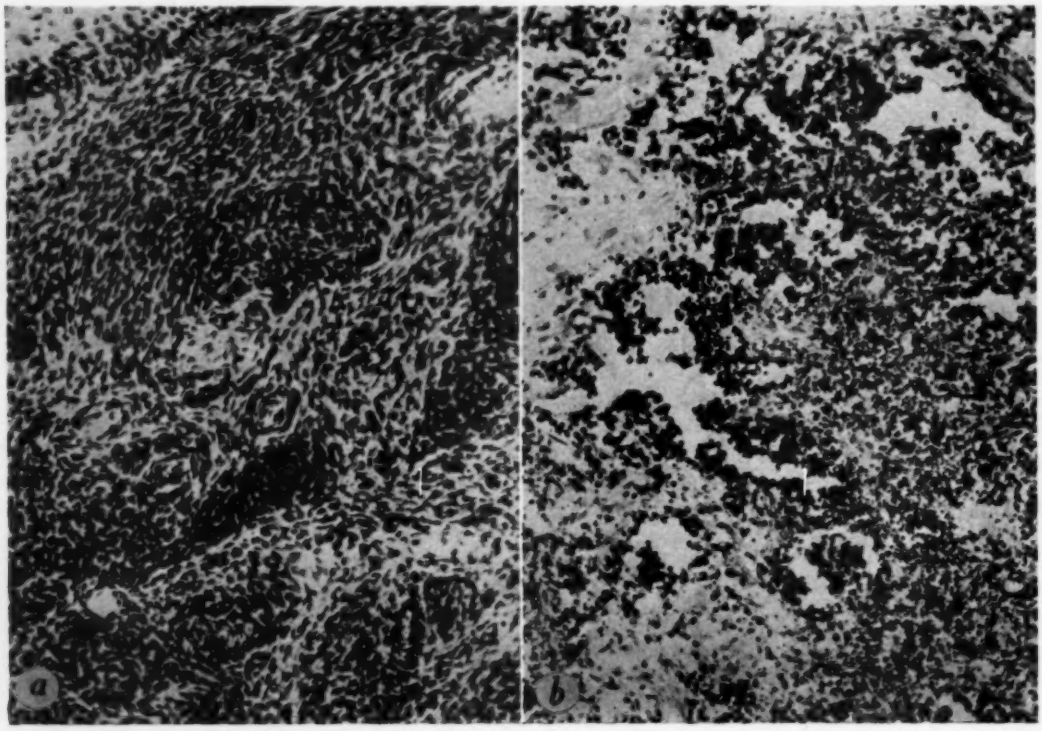

FIG. 2. *a*, Case III, hemangio-endothelioma, grade 1, showing the formation of vessels; also a development of spindle cells comparable to those seen in fibrosarcoma (hematoxylin and eosin ×130); *b*, Case IV, hemangio-endothelioma, grade 2, showing the formation of vessels and large vascular spaces lined with endothelial cells (hematoxylin and eosin ×125).

the left of the cervix. The uterus was of normal size.

Diagnostic curettage was performed. The uterus was found to be extremely friable. For this reason total abdominal hysterectomy was carried out. The pathologist reported that chronic metritis had been present, with moderate sclerosis of vessels and musculature. A hemangio-endothelioma of grade 1 was situated on the cervix (Fig. 2*a*). The patient's recovery was uneventful. On examination in 1944, she was well and the pelvis showed no evidence of recurrence. At the present writing (May, 1946), her son, a physician, reports that she apparently is perfectly well and has had no symptoms or signs referable to the pelvis. She has thus survived the disease for five years.

Case IV. A single woman, aged thirty-nine, was referred to the clinic in February, 1944, because of abnormal vaginal bleeding.

She had been perfectly well until July, 1943, when she had begun to notice that her usual periods of four to five days were prolonged to eight to ten days. This had continued until November, 1943, when she had had uterine bleeding lasting for two weeks, followed by continual spotting until the next period in December. This period had been manifest by increased bleeding, with large clots. She had then become weak and pale, and from that time onward menstruation had lost all semblance of regularity. Bleeding would continue for several days and stop for varying intervals, sometimes with spotting. She had had no pain; the discharge was minimal. About two weeks before her admission to the clinic severe uterine hemorrhage had occurred; she had been put in a local hospital, where blood had been transfused to her five times and blood plasma had been administered.

The history of the patient contained no relevant information. She had never married. There was no history of malignancy in her family.

General physical examination revealed a moderately pale, but not acutely ill, middle-aged female. The thorax, heart and various systems were normal. Vaginal examination disclosed introitus typical of that of a nulliparous woman. Two hard masses were felt in the left anterior vaginal wall; one near the hymenal ring, the other in the left fornix. Nodular masses and thickening were felt in the recto-vaginal septum and right fornix. The cervix was enlarged, firm and ragged, and bled easily. There was extension of stage III plus to the right broad ligament.

Inspection with the patient in the knee-chest position showed the neoplasm to be arising from the posterior lip of the cervix and stretching the anterior lip into a thin rim. A clinical diagnosis of carcinoma, stage III plus, of the uterine cervix was questioned pending report of pathologist. Specimens of tissue for biopsy were obtained from the cervix and the vaginal masses. All this tissue exhibited hemangio-endothelioma of grade 2 (Fig. 2*b*).

The reaction to the flocculation test for syphilis was negative. A roentgenogram of the thorax showed nothing abnormal. The value for the hemoglobin was 11.9 gm. per 100 cc. of blood. Erythrocytes numbered 3,640,000 and leukocytes numbered 6,000 per cubic millimeter. Leukocytes consisted of 25 per cent lymphocytes, 6 per cent monocytes, 64 per cent neutrophils, 1 per cent eosinophils and 4 per cent basophils.

Treatment administered to this patient consisted of a complete course of radium therapy by the intensive broken-dose method,[2] and four treatments with high voltage roentgen rays directed to the pelvis. The tendency toward bleeding from the vagina was rapidly brought under control. Marked resolution of the tumor was observed during the course of treatment.

Further limited radium treatment was administered in September, 1944. The patient returned from time to time in good general health and with few complaints referable to the pelvis. She was last seen in December, 1945, at which time she received additional roentgen therapy because of infiltration deep in the left side of the pelvis. Thus, to the time of this report, she has survived for two years.

COMMENT AND SUMMARY

Four cases have been reported in which a hemangio-endothelioma occurred in or on the cervix. Of the four patients, two are dead, but their death cannot be attributed directly to the neoplasm of the cervix. Two of the neoplasms occurred in unmarried women and two occurred in multiparous women. The youngest patient was thirty-nine years old; the oldest, sixty-two. The most prominent symptom was bleeding. In

those patients in whom menstruation still occurred there seemed to be a prolongation of the menstrual periods with increase in the amount of blood at the periods. Vaginal discharge was not a prominent symptom, even when the vaginal vault was filled by the tumor. The tumors seemed very radiosensitive, which usually is true of tumors of endothelial origin.*

Mayo Clinic
Rochester, Minn.

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* For discussion see page 690.

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CANCER OF THE CERVIX

BELLEVUE HOSPITAL METHOD OF TREATMENT OVER A PERIOD OF TWENTY-ONE YEARS*

By IRA I. KAPLAN, B.S., M.D., *Director Radiation Therapy Department*
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BELLEVUE Hospital, New York City, is the largest general hospital in this country, and receives each year a very large number of patients with malignant conditions. Because it is a free city institution the majority of patients are in the lower economic brackets and in most instances when affected by malignant conditions report directly to the hospital. In some cases they are referred from other institutions either already treated or when the malignant lesions are in the advanced stages, which the other institutions or private physicians refuse to care for.

All types of cancer cases are seen at Bellevue Hospital and naturally among these are a large number with gynecologic cancer, of which a considerable number suffer from cancer of the cervix.

Before the establishment of the Radiation Therapy Service at Bellevue Hospital in 1924 there was no organized method for treatment of cancer of the cervix with roentgen rays and radium. Most of the cases were treated wholly by surgery or in a make-shift manner by mediocre radiation procedures.

In 1924 a separate integral department for Radiation Therapy was established at Bellevue Hospital to provide roentgen and radium irradiation for both benign and malignant lesions. From the beginning of this service it was realized that a cooperative liaison established with the Gynecological Service of the hospital would offer the best means of handling gynecologic cancer. This arrangement was effected and has continued with great resultant benefit to the patients treated by both services.

Early in 1921[6] the Curie Institute in Paris initiated the treatment of cancer of the cervix wholly by roentgen and radium irradiation, and conclusively demonstrated the value of this form of therapy and its superiority over surgery in the cure of cervical cancer.

The method described by us[2] in 1926 at the meeting of the Radiological Society of North America in Milwaukee, with a few later modifications, was instituted at Bellevue Hospital in 1924 and has been carried on up to the present. A special applicator designed by one of us[3] was used in the radium therapy employed in all cervical cases treated. In 1931[4] and again in 1939[7] we reported the results achieved up to that time and in this present paper we are reporting on the results of our method of treatment over an experience of twenty-one years with 1,342 patients.

In the early development of the Radiation Service it was our custom to grade patients in two categories, those for which treatment might be indicated and those for whom only custodial care was possible. The greatest number of cases seen in the early days were advanced custodial cases. Later in 1938 with the publication of the League of Nations[1] formula for grading cervical lesions we divided our patients accordingly into four stages and that is the method employed by us today.

Because Bellevue is a large municipal hospital few early stage cancer cases come to us for treatment; therefore, seldom is a Stage I cervical cancer case encountered on our service. Most cases seen in the Radiation Department are advanced cases, commonly Stage III or IV.

New York City has a very large Negro population and one would expect a large number of cases of cervical cancer in Negro

* Presented at the Twenty-eighth Annual Meeting, American Radium Society, San Francisco, Calif., June 28–29, 1946.

TABLE I

RACIAL DISTRIBUTION

Jewish	25
Negro	163
White	707
Not recorded	46

women. However, only 163 were of this race in our service. One reason for so few is perhaps the fact that pelvic infection is not infrequent in young Negro women and radical hysterectomy is not an unusual operative procedure in these cases, leaving fewer older Negro patients in whom cervical lesions might become cancerous.

There were 707 white patients treated and in 46 cases color was not recorded.

Because New York City has a very large Jewish population it is of interest to note whether or not the incidence of cervical cancer is as great among Jewish as among Christian women. Vineberg[9] first called attention to the infrequency of cancer of the cervix noted in Mt. Sinai Hospital the largest general American-Jewish hospital in New York. While as a whole the number of Jewish patients coming to Bellevue Hospital is still small, our survey bears out Vineberg's opinion that cercival cancer is not common among Jewish women. Of the 1,342 cases of cancer of the cervix seen by us at Bellevue Hospital since 1924 only 25 were in Jewish women. The reason for this small number is not definitely understood. Perhaps the biblical Mosaic hygienic laws observed by Jewish women during menstrual periods has something to do with the apparent immunity of the majority of them (Table 1).

TABLE II

34 Stage IV cases were treated at request of services (3 alive)

7 lived 1 year
8 lived 2 years
8 lived 3 years
8 lived 4 years
1 lived 5 years
1 lived 6 years
1 lived 8 years

Of the 1,342 patients seen in the Radiation Service, 426 were so extensively involved when first examined by us that no active therapy could be attempted and these 426 patients were immediately transferred elsewhere for custodial care. Only 916 cases were held for active treatment by us. In this group there were 34 advanced cases which ordinarily would have been transferred for custodial care but were kept by us and treated because of special request. It is interesting to note that 3 of these are still alive and 1 lived eight years. Table II shows the survival figures of this group of 34 Stage IV cases; of the 916 cases treated 221 did not complete the prescribed course of therapy.

TABLE III

AGE DISTRIBUTION

Youngest.....23 yr.			Oldest.....83 yr.		
20–30	30–40	40–50	50–60	60–70	70 plus
69	216	309	196	96	30

Women of all ages were received in this service for treatment. The youngest was twenty-three and the oldest eighty-three years of age. The greatest number was in the forty to fifty year group (Table III). Of the 916 patients treated by us, 853 were married, 13 single. In 50 cases the marital status was not recorded. Of the known married patients 86 had not borne children and 777 had borne 1 or more, and of these, 418 bore 4 or more children (Table IV). It appears therefore that bearing children did have a definite influence on the formation of cancer in these cases.

Pathologically the lesions were of all types, the greatest number, however, being squamous cell (408), and the next largest group plexiform type (380). Table V shows the pathological grouping.

Patients were received in the Radiation Therapy Service from other services at Bellevue Hospital, from outside physicians, outside hospitals, and institutions. Some

cases, 79, had already received some form of direct treatment elsewhere but many were referred with out any treatment having been attempted.

In 1934 a new consultation service was established in conjunction with the Gynecological Department at Bellevue wherein the staffs of both services together examined all gynecologic tumor cases referred to either service. This we believed offered the best opportunity for determining the proper method of treatment. When irradiation was deemed advisable the patient was taken over for treatment by the Radiation Therapy Department.

Treatment of all cases depended upon the stage of the disease, the extent of involvement, the general condition of the patient and the presence of involvement of other organs, especially the ureters. Patients with conditions too far advanced for any active treatment were transferred to custodial institutions for care. Patients whose general condition was poor were cared for with building up procedures, diet, transfusions, chemotherapy, hygiene, etc., before active irradiation was administered (Table VI).

During the past ten years in all cases roentgenographic investigation of the genitourinary tract was carried out in order to determine the presence or absence of kidney or ureteral involvement before irradiation was used. In this way we were able to forestall untoward sequelae in many instances and explain symptoms referable to the genitourinary tract often improperly blamed upon radiation therapy. In this way, too, renal involvement could be properly cared for before irradiation was employed. These precautionary measures have often helped to tide patients over critical conditions and to preserve life.

Irradiation was planned for and outlined according to the extent, type and character of the local lesion. The method employed was that instituted by us at Bellevue Hospital in 1924 and described by one of us.[5] This method of treatment has been persistently followed since then with slight variation required by occasional exigencies. Based on our experience over a period of twenty-one years, we believe the irradiation procedure practiced by us to be the most effective and readily administered treatment for cancer of the cervix.

TABLE IV

MARITAL AND CHILDBEARING RECORD

Married...853	Unmarried...13	Not recorded...50
Patients	had	No. children
86		0
129		1
132		2
88		3
418		4 and more
50		unknown
903		
13	patients unmarried	
916	total	

TABLE V

Pathology	No.
Unknown	78
Advanced carcinoma	34
Plexiform	380
Squamous cell	408
Basal cell	5
Two types of malignancy	10
Three types of malignancy	1
	916

TABLE VI

CHARACTER OF PATIENTS RECEIVED

Patients transferred to City Cancer Institute because of too advanced stage of lesion	426
Patients who had hysterectomy before admission to Bellevue Hospital	61
Patients treated by irradiation before admission to Bellevue Hospital	79
Patients in whom treatment was begun but not completed at Bellevue Hospital	221
Patients who had complete therapy at Bellevue Hospital	555
Total	1,342

Because of our experience we definitely believe that roentgen therapy should precede the local application of radium, because it is extremely effective in controlling pelvic involvement, alleviates infection and often appreciably reduces the local lesion. In our opinion it is also necessary at the same time that a course of intensive vaginal hygiene be instituted to alleviate much of the local infection present in nearly all cases. This method has persistently been followed by us except in the very few instances where acute severe local hemorrhage required immediate local cauterization of the lesion with radium.

We did not find intravaginal roentgen therapy very feasible in our cases nor effective in the few instances in which we tried this method of procedure. It is definitely not adaptable to the advanced cases with vaginal atresia.

Roentgen therapy was carried out in all cases with the conventional 200 kv. high voltage roentgen rays through 0.5 or 1 mm. Cu, or Thoraeus filter. In the usual case, the roentgen irradiation was administered through four pelvic fields, two anterior and two posterior. In some cases of marked pelvic involvement or in obese women additional lateral and perineal fields were utilized. The dose given is 1,800-2,000 r (measured in air) to each field. In the advanced cases, and where residual malignancy is present following radium therapy, an additional course of roentgen therapy is administered, the dose depending upon the extent of the residual disease present.

Following completion of the roentgen therapy local radium therapy was administered as previously described by us, using the rubber colpostat devised by one of us (I.I.K.), which we still believe to be the most effective type applicator for this procedure. Both the uterine canal and the cervix were treated in all cases except where previous hysterectomy had been done. The usual total radium dose given was approximately 7,000-8,000 mg-hr., 4,500 mg-hr. to the cervix, the balance to the uterus. A larger dose was given in the uterus where the malignant condition involved the cervical canal.

In 61 cases previous hysterectomy had been done. In some of these hysterectomy was complete, in others only a supracervical procedure had been carried out. Treatment in all these types was first commenced with pelvic roentgen irradiation followed by local radium application. The type of radium therapy applied depended upon the condition present and the type of previously performed operation.

In some instances we departed from the general procedure to improvise special applicators for applying the radium to a particular condition depending upon the exigencies of the case. The results achieved were most heartening, especially when in most cases we were dealing with the advanced type of lesion not acceptable for active therapy elsewhere.

One of us[8] in 1940 investigated the factors influencing the prognosis in the treatment of cancer of the cervix.

In correlating the final results with the clinical findings before therapy was instituted we found that:

1. In cases of Stages I and II, a good prognosis may be given with reasonable assurance if proper treatment is employed without delay.

2. In Stage III prognosis should be guarded, as grading will depend upon the personal experience and interpretation of the examiner. Some cases closer to Stage II will give good results, while others closer to Stage IV, or borderline cases, may not respond at all.

3. Histopathologic grading may help but in some cases of Grade 3 epidermoid carcinoma we may fail, while in other Grade 1 or in presumably radioresistant cases we may obtain a cure.

4. Only 3 patients with a truly Stage IV grading have survived the five year period.

5. Some cases clinically diagnosed as Stage IV were not really as advanced as

they were believed to be from the first examination, as associated infection had interfered with the proper interpretation of the case. It is quite impossible to separate some cases from the hopeless and to make a definite prediction as to the outcome until the infection is cleared up.

6. If at all possible, treatment may be attempted even in clinically hopeless cases, with an occasional success.

7. Success in all cases is governed by the general condition of the patient, stage of the disease, quality of radiation employed, continuity of treatment, and individual susceptibility.

8. Complications arising from the extent of the disease upon admission, as well as concomitant diseases, expecially syphilis, will influence the prognosis.

To these opinions after twenty-one years of experience we still adhere.

Of the 916 cases treated by us 179 are alive five years or more; 60 are alive ten years or more. Eight patients developed recurrence or metastases seven and eight years after treatment. There were 34 cases we classified as hopeless, Grade 4, whom because of special request we undertook to actively irradiate. Of these 1 lived eight years, 8 lived four years. Table II shows the duration of life in all of these 34 cases. Because of the apparently beneficial

Table VII

			Alive 5 yr. or more	Per Cent
Total		1,342	179	13.3
Sent to City Cancer Institute without therapy	426	916	179	19.5
Previous hysterectomy	61	855	179	20.1
Previous therapy	79	776	179	23.1
Not completed therapy in Bellevue Hospital	221	555	179	32.1
Treated but transferred to City Cancer Institute	34	521	179	34.3

Table VIII

COMPLICATIONS

5 patients had diabetes
4 patients had cancer of the breast
2 patients had hypernephroma
8 patients had pulmonary tuberculosis
2 patients had hyperthyroidism
1 patient had an associated pregnancy
2 patients developed metastases to lymph nodes
6 patients developed metastases to bones
4 patients developed local recurrence (all 7–8 yr. after therapy)
1 patient developed polycythemia vera
2 were transferred to the State Hospital as psychopathic patients

results achieved we have been inspired to use greater effort in an attempt to succeed in treatment even in the advanced cases.

In 221 cases, treatment was not completed because the patient left our jurisdiction for one reason or other and for this reason results in these could not be ascertained by us. These cases are recorded among the dead. Table VII gives the details of our results.

In our statistical recording we have listed as dead many patients who did live five or more years after treatment; some lived ten years.

In 36 cases other complicating conditions were encountered. In 1 case pregnancy coexisted with cervical cancer. Table VIII lists the complications noted. In all these cases irradiation in no way adversely affected the associated complicating disease. The associated complications must be properly cared for before or during the course of radiation therapy in order that the best results may be achieved.

Based on our experience of over twenty-one years we believe that irradiation is the best method for the treatment of cervical cancer. In any but Stage I cases it is the method of choice. Even in Stage IV cases irradiation often controls the condition and prolongs life in comfort. Irradiation is best administered by a combination of roentgen and radium therapy with the roentgen therapy administered first unless

persistent severe hemorrhage demands immediate cauterization of the bleeding area by radium.*

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* For discussion see page 690.

Vol. 57, No. 6

INTRAVAGINAL RADIATION THERAPY*

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INTRAVAGINAL radiation therapy is not a new procedure. In 1920, Merritt[6,7] achieved rather spectacular results by treating cervical cancer with unfiltered roentgen rays through a glass speculum. Erskine is also a pioneer in this field, and he has developed various types of specula for the short anode surface distance and has used 25 to 30 cm. distance.[2,3,4]

Several years ago, I became dissatisfied with my method of treating cancer of the cervix by using radium and external irradiation. Therefore, I began to study the cervix and uterus at the autopsy table, and I found that the anatomical relationships of the cervix and uterus vary a great deal. The cervix is not always in the center of the pelvis, there may be anteversion, retroversion, or lateral deviations. The uterus may be anteverted and anteflexed so that it lies at right angles to the vagina, and it may rest on the bladder. These potential variations of the cervix and uterus made it obvious that there could be devised no standard method for treatment with radium application from the vaginal surface.

As is well known, the spread of cancer of the cervix is by direct extension into the paracervical tissues and by lymphatic drainage into the broad ligaments and regional lymph nodes. This spread may be either generalized or confined to one or the other fornix with or without involvement of the vaginal wall. It is important to bear in mind at all times that this extensive lymphatic area is open to invasion even in the clinically early cases, the so-called Grade 1 cases. All these cases should be examined with extreme care. A few years ago, this was forcibly impressed on me when biopsy done in an early case showed the cancer cells lying in the lymphatic vessels. Figure 1 shows a section of the bladder wall of a patient with cancer of the cervix in which the lymphatic vessels are filled with carcinomatous cells. Any manipulation could easily force these cancer cells into the lymphatic vessels and produce distant metastases.

To arrest this condition, the goal is to obtain uniform irradiation to all cancer cells throughout the pelvis. The question is how to attain that goal with the best results. Intravaginal therapy is apparently one of the best methods now available for dissemination of uniform irradiation.

The importance of uniform dosage throughout the probable tumor area cannot be too emphatically stressed. If one part of the tumor receives a dose less than the lethal dose, the tumor will probably recur. In other words, the dosage received must equal the minimal lethal dose, and if it exceeds it, then the excess must not be beyond the normal tissue tolerance.

Sandler[10,11,12] has shown that the vagina varies in size, and he stated that "Each size of vagina must have its own variation of technique, if full use is to be made of the available parametrial tolerance, which differ with each size of vagina. The actual disposition of the radium shown in these patients are, as might be expected, different from those anticipated in a theoretical technique. Thus, if the dose received at selected points in the pelvis were based as a routine on what may be expected from these theoretical distributions, gross inaccuracies may occur. An error of 1,000 roentgens as between the right and left sides is not uncommon and a variation of up to 2,000 roentgens in dose delivered by the same technique may occur in different sizes of vagina."[10]

Wasson and I found this to be true very often, and we began to use intravaginal therapy in an attempt to treat the entire

* Presented at the Twenty-eighth Annual Meeting, American Radium Society, San Francisco, Calif., June 28–29, 1946.

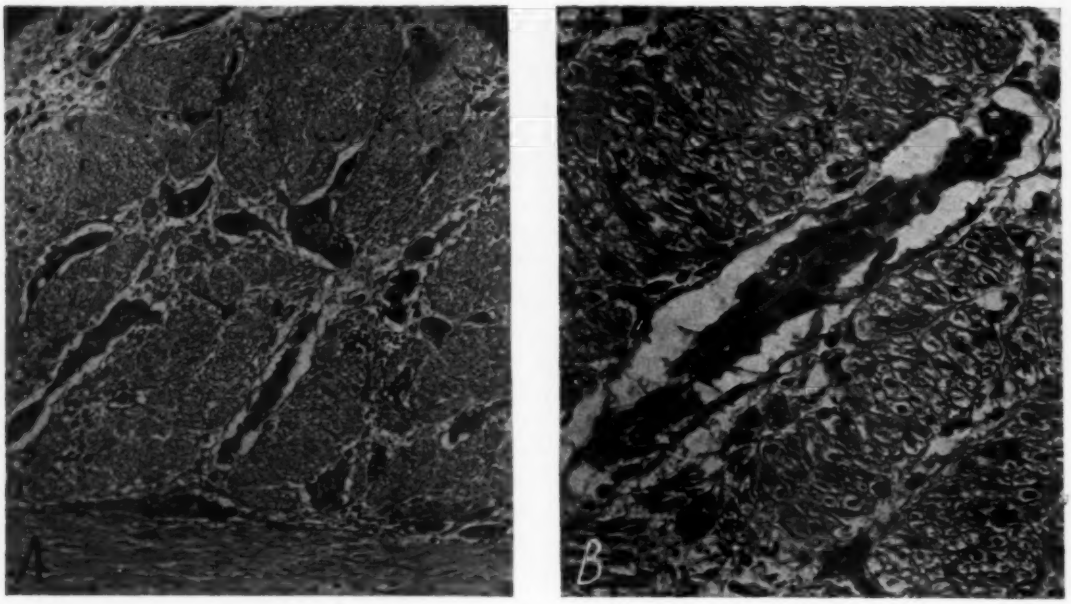

FIG. 1. *A*, metastatic carcinoma from cancer of cervix invading bladder wall. Lymphatic blocked with carcinomatous cells. ×125. *B*, same as *A* except magnified, showing one lymph channel filled with carcinomatous cells. ×375.

pelvic area adequately. The intravaginal method makes the treatment comparable to that of a local lesion, such as a cancer of the lip. Variation in the size of the vagina is compensated for by varying the size cone used. Dosage may be increased until the desired reaction is obtained evenly throughout the adnexa.

The ideal method of treatment to obtain the desired effect is to concentrate the roentgen radiation upon the particular organ. Such concentration of energy can only be assured by the most exact orientation of the organ's position in the individual patient. Therefore, in each case it is necessary to determine the following data: (1) the position of the lesion as projected upon the surface of the body in relation to certain fixed points; (2) the depth of the lesion from the surface of the body. Then the

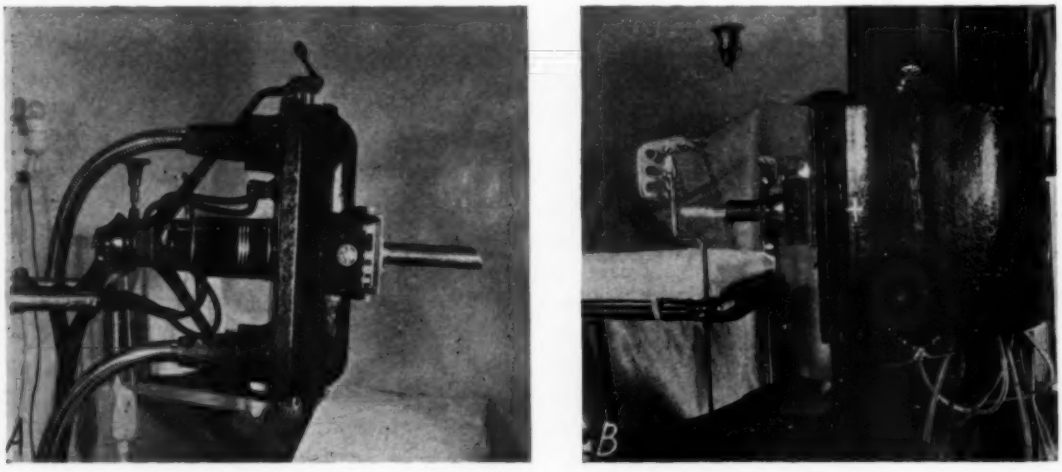

FIG. 2. *A*, 140 kv. tube head with intravaginal cone attached. *B*, 200 kv. tube head with intravaginal cone attached.

technique necessary to deliver the lethal dose to this area must be determined. Our technique has been published,[13,14] and therefore it is not necessary to repeat the detailed procedure, but it seems advisable to call attention to certain points.

By dividing the pelvis into five fields, namely, two anterior, two posterior, and one perineal field, better distribution of dosage throughout the pelvis is obtained. These areas vary in size depending upon the size of the patient. The intravaginal cones are of metal so there is no scattered radiation to the urethra, labia and the superficial tissues, and they are adaptable for either the 140 kv. or the 200 kv. machine. When using the 140 kv. machine, our technique is: 25 cm. distance, 3 mm. aluminum filter or 0.25 mm. copper, 900 r per treatment (half-value layer 3 mm. aluminum is 5.50 mm. aluminum; half-value layer 0.25 mm. copper, 0.44 mm. copper). The 200 kv. technique is: 50 cm. distance, 0.5 mm. copper plus 2 mm. aluminum, 500 r per treatment (half-value layer is 1.0 mm. copper) (Fig. 2).

This technique requires the physician's planning and supervision of each treatment; it is time-consuming and requires exact placing of the cones to obtain the proper dosage to each area, and in a busy clinic it might be difficult to administer; however, the results we have achieved seem to warrant continuance of it in our practice.

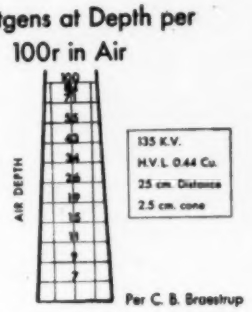

Fig. 3. Distribution of intensity from Braestrup's work.

Depth dose charts for both 200 kv. and 140 kv. roentgen therapy have been published. The ones we use correspond to the charts of Braestrup[1] for 140 kv. (Fig. 3) and of Quimby[8,9] for 200 kv. (Fig. 4).

External irradiation is given before the radium or intravaginal therapy in order to try to stabilize the cancer cells and prevent any lymphatic extension. Figure 5 is a

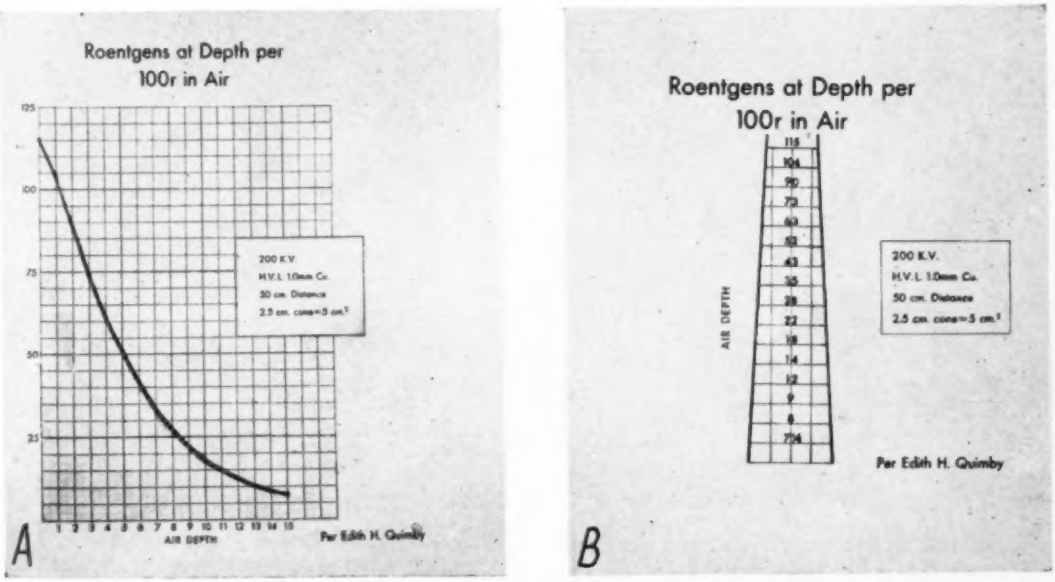

Fig. 4. *A*, percentage depth dose curve from Quimby, *B*, distribution of intensity from *A*.

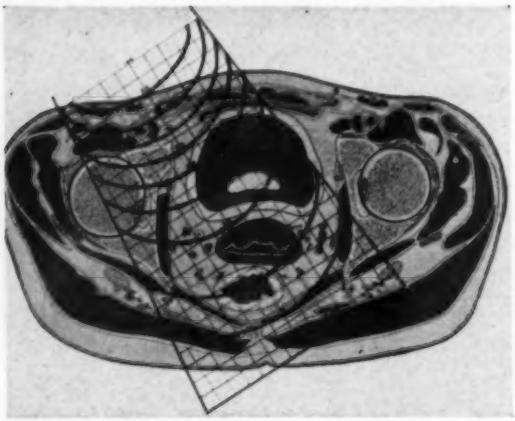

Fig. 5. Cross section of pelvis 18 cm. deep with isodose chart for 10 by 10 cm. field, showing depth dose to cervix.

cross section of the pelvis with isodose chart to show the depth dose at the site of the cancer.

I found practically no mention in the literature of the perineal field which, in my opinion, is a very important although much neglected field of treatment. My reason for this is that through it more radiation may be delivered to the cancer site than can be given through lateral fields over the hips, and also, radiation over the latter fields may affect the bony structures and cause a bony change which may result in pathological fracture. The perineal field must vary in size according to the size of the patient. If too large an area is used, there is a resultant danger of local reaction to the anterior or posterior fields. Figure 6 is a chart showing how the depth dosage may be added to the site of the cancer.

Administering the external irradiation usually requires about three weeks as it entails using 200 kv. technique and giving 250 r daily for a total dosage of 1,000 r over each field.

Intravaginal therapy is started before the reaction begins in the perineal area so that the tissues are not too tender for the introduction of the vaginal cones. The largest one that the vagina will tolerate is selected, generally the 2.5 cm. or 3.0 cm. cone, and it is angled to direct the rays into the cervix and broad ligaments or any desired part of the pelvis. An excellent

Fig. 7. Diagrammatic sketch showing the relationship of the cones to the areas treated and uterine adnexa.

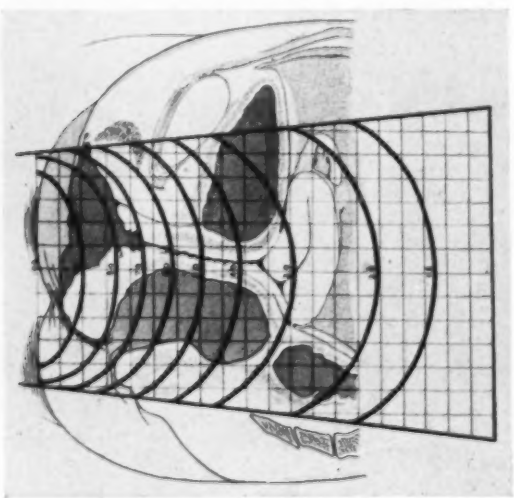

Fig. 6. Sagittal section of pelvis 18 cm. deep with isodose chart for 10 by 10 cm. field, showing depth dose to cervix.

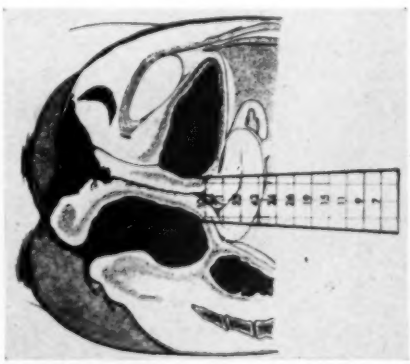

Fig. 8. Sagittal section of pelvis 18 cm. deep with distribution chart for 140 kv. using 2.5 cm. cone.

plan to give uniform distribution of radiation throughout the pelvis is shown in Figure 7, and Figures 8 and 9 are charts which show the depth dose using the 25 cm. cone intravaginally. The first treatment is directed to the cervix as shown in the area indicated by *1* in Figure 10. Treatment then proceeds clockwise through areas numbered *2*, *3*, *4* and *5*, or occasionally two areas may be given at one time such

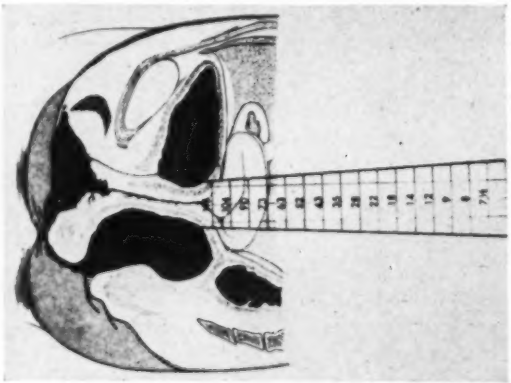

Fig. 9. Sagittal section of pelvis 18 cm. deep with distribution chart for 200 kv. using 2.5 cm. cone.

as *2* and *4*, or *3* and *5*. It must be remembered that the rays are limited to the area conforming to the end of the cone.

Both external irradiation and intravaginal therapy should be repeated in four to six weeks. Thus, there can be given in each case the maximum dosage which the vaginal wall and the pelvic viscera will tolerate. The reaction from intravaginal therapy is the same as that from radium and external roentgen irradiation. Occasionally there is a delayed reaction, that is, an ulceration, increased discharge and occasionally some bloody mucus about three months after treatment, but local treatment will control this condition and cause it to subside. I have found that over 5,000 r delivered to the site of the cancer in three months may elicit this delayed reaction.

In our experience, during the last five years, this technique has produced better results than only the use of external irradiation and radium. Contraindications to its effectiveness are vaginal atresia, vaginismus and the narrowness of the vagina in unmarried women, which make the introduction of the cone too painful or

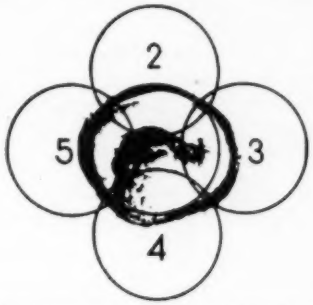

Fig. 10. Diagrammatic sketch of cervix showing the areas treated as they would be seen through the cone.

impracticable. In some of these patients, after anesthesia, and radium has been inserted into the cervix, the vagina will permit a small cone so that additional therapy may be applied to the broad ligaments. It must be borne in mind that there is no one method of treating all cases; each one must be carefully analyzed, evaluated, and the method chosen which offers the best results.*

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THE USE OF LONG INTERSTITIAL RADIUM NEEDLES IN THE TREATMENT OF CANCER OF THE CERVIX*

By GEORGE W. WATERMAN, M.D., RALPH DiLEONE, M.D., *and* ELLSWORTH TRACY, M.D.

PROVIDENCE, RHODE ISLAND

THIS paper is the fourth of a series on the use of interstitial radiation as practiced at the Rhode Island Hospital. An earlier report, in 1930, by Pitts and Waterman,[1] dealt with 92 cases treated at this clinic (1921—1925) prior to the use of the interstitial radium needles. At the time of this publication, the authors had been using the long needles for several years. Although too few cases on which five year survivals could be reported were available, primary results were very encouraging. They stated the general principle on which these needles were used, i.e., "the needles are thrust into the tissues about the cervix placing them as near as possible to what is felt to be the advancing edge of the growth." The method has never been changed and the planned treatment differs only in that now roentgen therapy is used in the great majority of cases.

Interstitial radiation for the treatment of cancer in many locations in the body, including the cervix, has been quite widely employed almost from the first use of radium. Many authors have reported on the use of interstitial needles of various types and of radon seeds in the treatment of cervical cancer (Ward, Healy, Meigs, Taussig, Scheffey, Teahan, Weatherax, C. L. Martin, and others). Most of these writers use a quite different type of needle than has been employed in this clinic, the needle usually being shorter, the filtration being of a different type and the strength of the applicator being greater. Arneson, and Nolan and Quimby have discussed the use of interstitial sources of radiation in cancer of the cervix and approved in principle of the idea of small sources widely distributed through the parametrium and paracervical tissues with heavy filtration and long time interval.

Today, we wish to bring our experience of twenty years with the long needle technique up to date. We feel greatly honored to have been invited to appear again before the American Radium Society. In this paper it is our wish to review (1) the type of needle used, (2) the technique of application, (3) to add 72 new cases to the 507 reported, (4) to discuss the last five years' work, 1936 through 1940 as to five year survivals, complications and immediate mortality and (5) to discuss roentgen therapy as related to this series.

The type of needle used has assumed great importance in our eyes as having a bearing on results obtained. The needle is a thin-shanked, rather delicate instrument. The 3 milligram needles have an over-all length of 60 mm., an active length of 45 mm., 1 mg. radium element, 1 by 5 cm. outer length. The radium is distributed throughout the active length evenly. The wall thickness is 0.5 mm. of platinum-iridium. The external diameter of the needle is 1.65 mm. about the diameter of a No. 17 gauge intravenous needle. The 2 mg. needles have an over-all length of 44 mm., an active length of 30 mm. The wall thickness and external diameter are the same as for the 3 mg. needle. In addition to the needles, a tube, 52 cm. in length of Monel metal 1 mm. in thickness, contains a 20 mg. radium element capsule filtered by 0.5 mm. platinum. Here again the radium is evenly distributed throughout the active length of the tube. The needles have a trocar point which becomes very dull rather soon after being put into use and is never sharpened. These needles

* Presented at the Twenty-eighth Annual Meeting, American Radium Society, San Francisco, Calif., June 28–29, 1946.

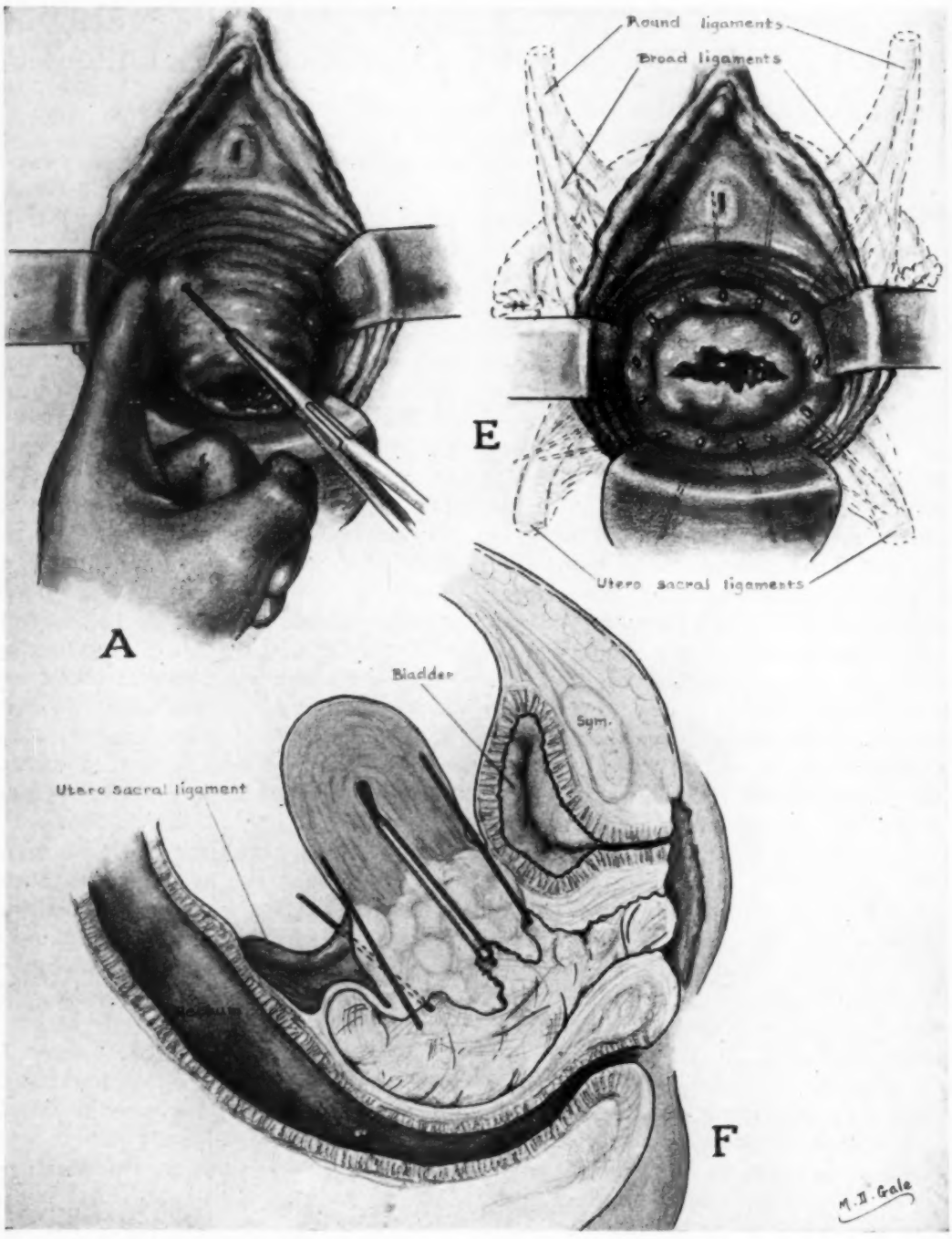

FIG. 1

can be inserted into and about tumor tissue with a minimal amount of trauma and can do very little harm in the tissues as single units. It is doubtful if much harm would occur even if a needle came to lie across a fairly large blood vessel or the ureter. The relative freedom from complications of hemorrhage or stenosis of the ureters in our cases would seem to bear out this fact.

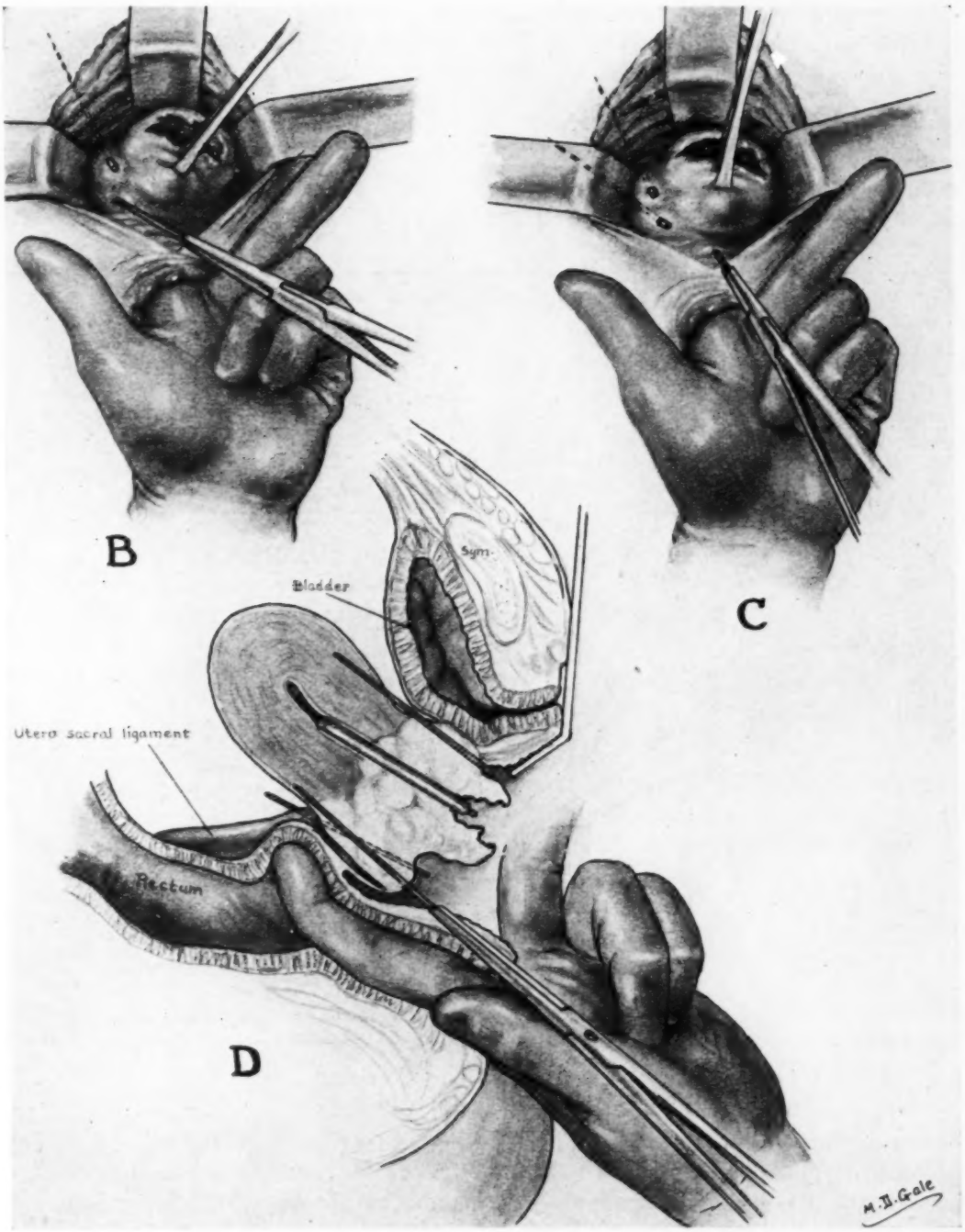

Fig. 2

The plan of insertion of the needles is the same as first outlined in 1930 and reiterated in later papers. Under good exposure and relaxation under anesthesia in the operating room with good light, an examination is made. The extent of growth and the direction of invasion whether forward under the bladder, backward towards the rectum or laterally toward one or both sides is determined. This examination in-

cludes a rectal examination to determine the extent of parametrial involvement. The size of the lesion is carefully noted. The long 3 mg. needles are then inserted usually at the sides through the lateral fornices of the vagina, and into the tumor tissue as close to the outer palpable margins of the growth as possible, usually about 1 to 1.5 cm. apart. place. If the growth anterior to the cervix is extensive, extending 6 cm. or more as palpated bimanually, a long needle is used under the bladder. If the cancer is close to the bladder, all the more reason for having the needle there. Usually, however, the shorter 2 mg. needles are used anteriorly and posteriorly. The posterior needles may

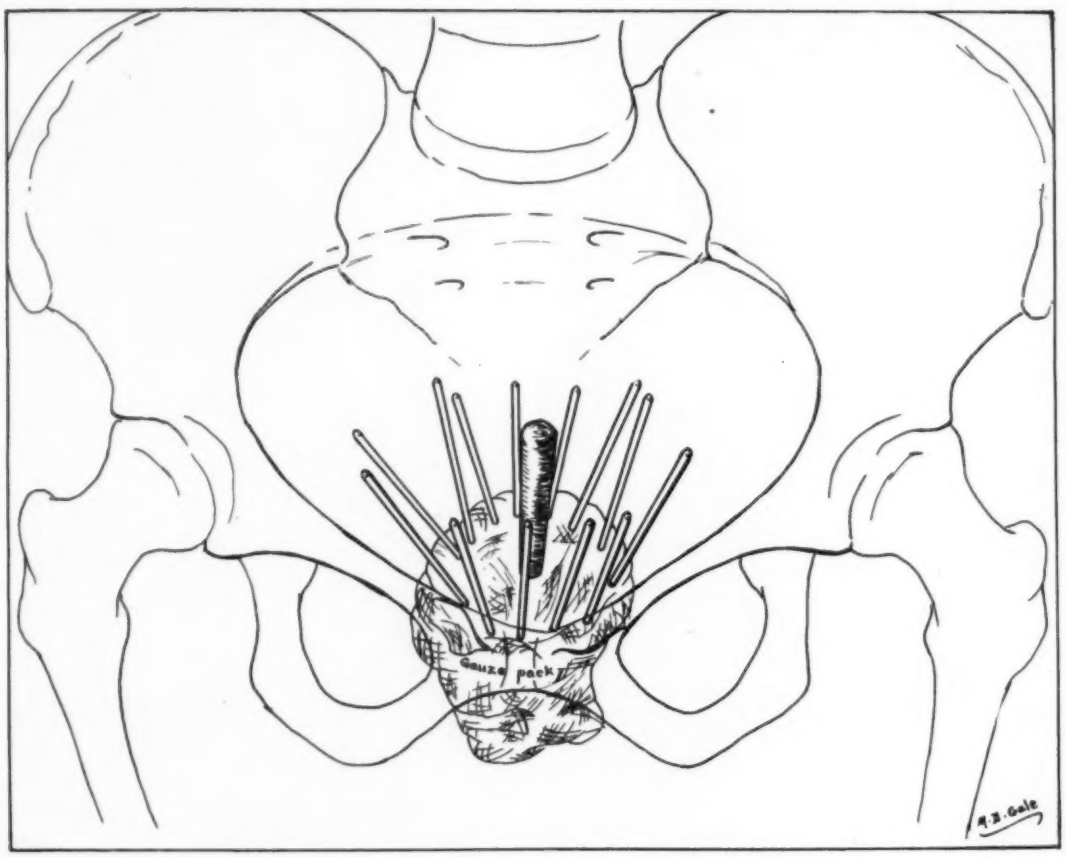

FIG. 3

It is not intended to have these needles lying loose in normal tissues. Great care should be exercised before the insertion of the needle, as to just where it is going, so that once placed, it need not be removed and reinserted. It is probably better to leave a misplaced needle alone rather than to pull it out and reinsert it. The small amount of radium in any single source will not do any particular harm even if a little out of be guided into place by the rectal finger. The 20 mg. capsule is placed in the cervix and is held in place by passing the deknatel leaders through the lips of the cervix anteriorly and posteriorly. The vaginal fornices and the entire vaginal space is packed tightly with iodoform handkerchief.

It has never been our idea that any definite, universal pattern or arrangement of needles is possible, which will destroy

every type and kind of cancer in the pelvis. A sufficient number of needles must be used to meet the individual situation. In different types and extents of growths anywhere from three to twenty needles have been used. The average number lies between ten and fifteen. Eight needles would suffice for the smaller Stage II growths, twelve to sixteen for the larger ones. The usual dose for a Stage II or III growth would be between 6,000 and 9,000 mg-hr.; the largest dose is 12,000 mg-hr.

RESULTS

With the addition of 72 new cases to the 507 cases previously reported, we now have 579 cases, absolute, in this clinic. These cases have been classified according to the Schmitz method. Table I shows the survival rates by years. Of these 579 cases, 57, or 9.8 per cent, were not treated with radium because they were too far advanced or unsuitable for treatment. Of this group, 1 patient treated by roentgen irradiation alone survived five years. Our relative figure of 522 cases treated shows 192 five year survivals, or 36.7 per cent of the group. A few of these cases were treated with radium without the use of needles. Four hundred and eighty-five cases treated with needles, or 92.9 per cent of the total treated cases, had a survival rate of 37.1 per cent for five years.

A review of the last five years, 1936–1940 (Table II), on which five year survivals could be reported would seem of interest as showing possible improvement. The method of radium treatment has not

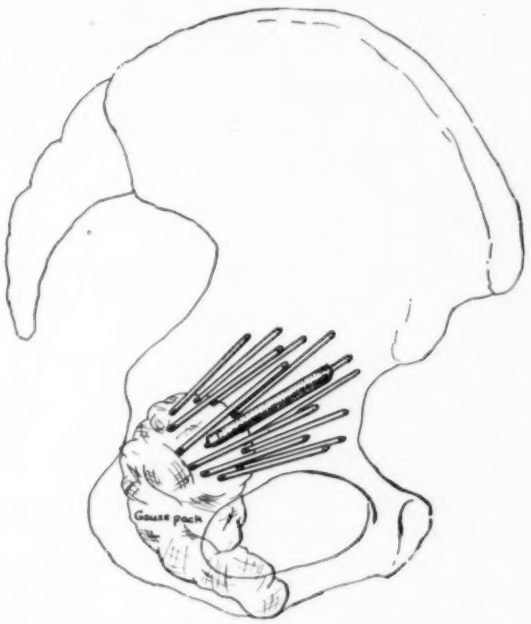

Fig. 4

Table I

CLASSIFICATION AND SURVIVAL

Rhode Island Hospital, 1926–1940
579 Cases Absolute

Stage (Schmitz)		No. Cases	Survival					5 Yr. Per Cent
			1 Yr.	2 Yr.	3 Yr.	4 Yr.	5 Yr.	
I	(4.0%)	23	23	22	21	19	18	78.2
II	(30.0%)	174	157	127	117	112	103	59.2
III	(42.3%)	245	173	119	88	73	69	28.1
IV	(23.7%)	137	24	8	6	3	3	2.1
Absolute	(100.0%)	579	377	276	232	207	193	33.3
Not treated with radium	(9.8%)	57	1	1	1	1	1	
Treated (relative)	(90.2%)	522	376	275	231	206	192	36.7
Radium (not needles)	(7.1%)	37	27	23	21	13	12	32.4
Radium needles	(92.9%)	485	349	252	210	193	180	37.1

TABLE II

CLASSIFICATION AND SURVIVAL

Rhode Island Hospital, 1936–1940
198 Cases Absolute

Stage (Schmitz)		No. Cases	Survival					5 Yr. Per Cent
			1 Yr.	2 Yr.	3 Yr.	4 Yr.	5 Yr.	
I	(3.0%)	6	6	6	6	6	6	100
II	(28.3%)	56	51	43	41	40	38	67.8
III	(50.0%)	99	65	46	33	30	30	30.3
IV	(18.7%)	37	8	3	3	3	3	8.1
Absolute	(100.0%)	198	130	98	83	79	77	38.9
Not treated with radium	(13.6%)	27	1	1	1	1	1	
Treated (relative)	(86.4%)	171	129	97	82	78	76	44.4
Radium (not needles)	(2.9%)	5	3	3	3	3	3	60.0
Radium needles	(97.1%)	166	126	94	79	75	73	43.9

varied in these last years but we have used roentgen irradiation far more extensively and this may contribute to some extent in better results as shown in the five year survivals. In this period 198 cases were seen for examination at our clinic. Of these, 27 were considered not suitable for treatment with radium which left a total of 171 cases which were treated with radium. Seventy-seven of the 198 absolute survived five years, or 38.9 per cent. Seventy-six of the 171 treated with radium survived five years, or 44.4 per cent relative. Five cases were treated with radium but not with needles, leaving 166, or 97.1 per cent, of the treated cases in which needles were used. Seventy-three of the 166 cases survived five years, or 43.9 per cent.

IMMEDIATE MORTALITY

171 treated cases—2 deaths—1.2%

In the last five years, 1936–1940, we have had 2 deaths following the use of interstitial radium needles. One, in 1937, was a very advanced case with a large, broken-down infected growth, which had had primary treatment elsewhere, followed by roentgen irradiation without improvement, a case which should not have been treated at all. The patient died on the sixth postoperative day of sepsis. The other death in the same year, a Stage III case, which was bleeding severely, was treated with needles and died on the twentieth postoperative day, two weeks after the needles had been removed, of a severe hemorrhage. Two cases not treated with radium died in 1936; one a Stage III died, twenty-nine days after completion of roentgen therapy, from pyelitis and septicemia. The other, in 1936, a very advanced Stage IV died, ten days after having had three roentgen treatments, of uremia. In 326 cases, 1938-1945, we have had no immediate mortality. Recently, in March, 1946, one of our patients died of pulmonary embolus on the tenth day after the radium was inserted, the third day after its removal. She was just getting up for the first time, our first immediate mortality in eight years.

COMPLICATIONS

Tables III, IV and V have been prepared showing complications, urinary and intestinal, for the years 1936–1940. It does not seem that our incidence of severe complications is higher than it should be or than has been reported by others using different forms of radium applicators. The

TABLE III

URINARY COMPLICATIONS DUE TO IRRADIATION
1936–1940

	Stage II	Stage III	Stage IV
Vesicovaginal fistulae	2	2	2
Hydronephrosis—due to irradiation and not cancer	—	2	—
Late ulceration of bladder—each 2 years after radium	3	—	—
Total of 171 cases treated with radium 6.4%	5	4	2

TABLE IV

INTESTINAL COMPLICATIONS DUE TO IRRADIATION
1936–1940

	Stage II	Stage III	Stage IV
Rectovaginal fistulae	3	2	2
Ulcerative colitis with hemorrhage, alive 8 years	1	—	—
Radium injury to ileum, resection and death	1	—	—
Ulceration of rectosigmoid, incidental autopsy finding	1	—	—
Ileovaginal fistula, died following ileocolostomy	—	1	—
Perforation rectosigmoid, 3 and 4 months after treatment	—	2	—
Vesicocolic fistula, 5 months after treatment, death	—	1	—
Rectal bleeding or severe tenesmus	3	8	1
Total of 171 treated cases showing complications	9	14	3

TABLE V

FISTULA FORMATION—SUMMARY 1936–1940

12 patients—7%—had fistulae at some time after treatment
3 were vesicovaginal fistulae
4 were rectovaginal fistulae
3 had both vesicovaginal and rectovaginal fistulae
1 ileovaginal fistula
1 vesicocolic fistula

TABLE VI

EFFECT OF ROENTGEN IRRADIATION ON FIVE YEAR SURVIVAL RATE
1933–1940

	Stage II			Stage III		
	No. Cases	5 Yr. Survival		No. Cases	5 Yr. Survival	
Roentgen irradiation used as part of primary planned treatment	55	35	63.6%	99	29	29.3%
Radium alone used in primary planned treatment	42	30	71.4%	54	13	24.0%

use of interstitial needles of the type described and in the manner used should not be accompanied and has not been accompanied by severe injury to bladder, rectum or ureters in more than a small percentage of cases.

Table VI shows a series of cases from 1933–1940 during which time deep roentgen therapy was being used in a considerable number of cases. Roentgen therapy was not used in all cases. Choice of roentgen irradiation as part of the primary treatment depended during those years on an individual estimation of the need of further radiation. Some bad reactions to added roentgen therapy made us a little cautious for awhile. The results based on five year survivals alone would seem to indicate that cases treated with radium without roentgen irradiation did a little better where the early stage was concerned. The Stage III cases seemed, however, to have been benefited by use of roentgen irradiation in that more of them survived five years. It is realized that this table does not tell the whole story as to the value of roentgen therapy. In cleaning up the badly infected case and thus bringing down the mortality and morbidity, preliminary roentgen therapy has a decided place. In the early case, however, where the infection is not bad, where the growth is entirely limited to the cervix and can be completely surrounded, the place of roentgen irradiation is not so clear. Patients certainly have much more bladder and rectal irritation where roentgen irradiation is used. In fact, the principle of shielding the center of the pelvis from the roentgen-ray beam with a lead strip has been adopted since 1912 in order to avoid these complications.

SUMMARY

A review of the method of treatment of cancer of the cervix uteri at the Rhode Island Hospital by the use of long interstitial radium element needles has been given. Details as to the type of needle and its method of insertion have been described with illustrative figures. Results, absolute and relative, are shown by tables for the whole group and for the 198 last consecutive cases treated through 1940. Tables are given showing immediate mortality and complications. The effect of roentgen irradiation on the five year survival rate is discussed.

CONCLUSION

We believe that the method outlined, of small sources in long radium element needles, widely distributed—gamma radiation—long time interval, has a distinct place in radium therapy of cancer of the cervix uteri. The use of interstitial radiation by the long radium needle technique has been shown to be highly effective with a distinct improvement in results over the last five years recorded.*

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* For discussion see page 690.

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THE RADICAL OPERATION FOR CANCER OF THE CERVIX*†

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IN TWO previous communications the radical operation for the treatment of carcinoma of the cervix has been discussed. At the present time 91 such operations have been done with a postoperative mortality of 0 per cent. It is therefore proved for the first time that this surgical procedure can be done in selected cases with a mortality equal to that of the radiation treatment of this disease. Five year results cannot be presented for the present series is too new. Three year results in a sufficient number of cases to give the trend of the results will be presented and these results demonstrate the great value of this operative procedure. It can now be definitely stated that in selected cases with the application of modern surgical methods, proper preparation of the patient, and the use of antibiotics, and the avoidance of injury to the blood vessels of the ureter, the operation can be successfully accomplished with little or no morbidity. In cancer of the cervix the use of less radical procedures than the so-called Wertheim operation have no place in the attack upon this disease. Too frequently surgeons are doing the Wertheim operation but their operation is but little more than or slightly more than the ordinary total hysterectomy. The radical operation consists of complete removal of all lymph channels and lymph nodes, the removal of at least one-half of the vagina, all of the parametrium, the posterior cul de sac, and the supporting ligaments and muscles to the vagina. It is a time-consuming surgical procedure but with care can be done satisfactorily with a minimum of damage to other pelvic structures. It was decided to carry out this operation only after seeing it done by modern experts such as Bonney of London and Warnekros of Dresden. The lymph node dissection is done after the method advocated by the late Dr. Taussig of St. Louis after close observation of his excellent technique. It is my opinion that no operator should attempt this procedure without first viewing the manner of the surgery done by those who have been doing it fairly regularly. It is difficult to understand the procedure as it should be done from textbooks for the radical procedure is a combination operation.

It should be distinctly understood and emphasized that the operation is not an attempt to compete with irradiation in cancer of the cervix. Irradiation is the present treatment of choice and it has not been proved that the surgical procedure is as good or better. Surgery distinctly should not be made the goal of all operating surgeons for all but a very few cases are much better handled by irradiation. The present interest in radical surgery is due to the fact that a few early cases do not respond well to irradiation. If this is a fact, then surgery may offer a way to cure this group. Radiation resistant cases cannot be selected at this time. If the radical operation can be done with a low mortality it might be wise to apply it to selected early cases. The lymph node problem is a real one if irradiation is ineffective against cancer in nodes, as believed by some. Surgical removal therefore might be of great value. The question of lymph node sensitivity has not been proved one way or the other for no one has absolutely determined whether or not lymph nodes with cancer in them are destroyed by roentgen and radium irradiation. At this point it might be well to present a case demonstrating what is suspected by our

* From the Vincent Memorial Hospital (Massachusetts General Hospital), the Pondville Hospital (Massachusetts Department of Public Health), and the Palmer Memorial Hospital.

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group in regard to irradiation of lymph nodes. One case does not prove anything but such examples are rare.

Mrs. C. H. (Private Case No. 6815) was chosen for a Taussig operation (lymph node dissection) because her local disease had done so well and it was felt that removal of lymph nodes might be of value to her. At operation it was found that there was a 2.5 cm. node in the right obturator region involving the veins deep in the fossa. It was felt that it would be impossible to remove the fixed node and so it was decided to use roentgen treatment of the tumorous node. A biopsy of the node was made which showed it to contain epidermoid carcinoma grade 2. The capsule of the node was sutured after the biopsy was removed. The patient was then given roentgen treatment directed at that node. Dr. Joseph Marks, the roentgenologist at the Palmer Memorial Hospital, knew exactly where the node was and he gave it 7,600 r through four fields with a 400 kv. machine, aimed directly at the node. It was never possible to feel this node after treatment. The patient gained weight, had no pain, and was in excellent condition at the end of five years. It was considered that this was proof that roentgen treatment could destroy cancer in the pelvic lymph nodes but, reporting at five and a half years, the patient had lost 20 pounds and a mass was felt in the region where the node was and a definite recurrence had taken place.

This case suggests the inability of roentgen treatment to destroy the cancer in this particular node but its great ability to retard its growth. It also demonstrates that the five year results of radiation treatment may not be definitive and that cancer in nodes may recur after five years. It suggests that if surgical removal can be accomplished more satisfactory results might be obtained.

MATERIAL

The material for this study came from three hospitals—the Vincent Memorial Hospital (Massachusetts General Hospital), the Pondville Hospital (Massachusetts Department of Public Health), and the Palmer Memorial Hospital of the New England Deaconess Group. Forty-nine cases are from the Massachusetts General Hospital; 33, from Pondville; and 9, from the Palmer Memorial Hospital. It is not easy to obtain cases for surgery and unless a surgeon is connected with a large clinic to supply him with cases the number per year will be very small. Our first patient was operated upon in September, 1939. In that year 2 were operated upon and by 1942 a fairly stable level of 17–20 cases per year was established. If 150–200 new cases are seen in the clinics per year, 20 surgical cases per year indicates that 7.5 to 10 per cent of all cases are early enough to be operated upon. Thus it is obvious that a true selection of cases has been made.

REASONS FOR THE OPERATION

The five reasons for doing surgery are presented below. In each paper upon this subject these reasons have been given and a repetition here is not out of place.

1. If the cervix has been removed, there is no chance for a recurrence in it.

2. If the cervix has been removed, no cervical cancer can regrow in it as a recurrence.

3. Certain cancers of the cervix are radiation resistant, a fact proved at the Pondville Hospital, where multiple biopsies are performed at the time the roentgen and radium treatment is being carried out.

4. There will be less damage to the bowel if surgery is undertaken. Lately, 46 cases of serious bowel injury have been found in our clinics.

5. From the work of both Bonney and Taussig it is obvious that patients with lymph node metastases can be cured by surgery in some instances, and I believe that it is not possible to cure with irradiation cancer in lymph nodes deep in the pelvis.

Cases are selected for the operation who are young, thin, and good surgical risks, and who have a growth that involves the cervix and not more than 1 cm. of the vagina from the cervix. Patients with definite infiltration into the pericervical tissue are not operated upon for during the surgical approach the area would certainly be cut across. Lymph nodes that can be palpated

are not contraindications for it is in these very cases that surgery might cure and where irradiation might fail. In patients with a large, proliferative growth where a spillage of cancer might be expected radium and roentgen treatment and radium in doses approximating one-half the usual dose are used. This destroys the local tumor and if any remains it is "sick" and growth from spillage is minimized.

We advocate strongly that the surgeon take the time to view the radical technique in the hands of a competent surgeon before undertaking it. The greatest danger is injury to the ureter and this can be prevented by leaving the ureter attached to the peritoneum as low down as possible and avoiding injury to the blood supply to the ureter from the internal iliac artery. Proper preparation of the patient is absolutely essential, as is the use of blood transfusions and antibiotics.

Fat, short women are difficult to operate upon and the dissection of the pelvis is not satisfactory because of the huge amount of fat in the areas of dissection. Older women are not included because they have not been proved to be good risks for this type of surgery. However, it is obvious that old people tolerate major surgical procedures well and it may be that they would stand the operation. It is proposed to extend the indications. Cervical cancer does extend down the vagina and this group with more extensive vaginal growth will be operated upon in a later series. It was essential to prove that the Wertheim operation could be done with a mortality lower than that shown by Dr. Victor Bonney before one would dare to advocate surgery as treatment. With the completion of 100 cases the mortality and morbidity will be recapitulated and if found satisfactory then surgery of more advanced cases will be advocated.

This paper presented before this Society is not the place to describe in detail the operative technique. Suffice it to say that it is a very radical procedure and that in well trained surgical hands should not prove too formidable. The dangers to the ureter have been overcome and other disasters are rare. One complication that does cause trouble occasionally is the fact that the dissection has been so broad that the sympathetic and parasympathetic fibers have been interfered with so that the patients cannot void. Some have been sent home on catheter drainage but finally all have been able to empty the bladder satisfactorily. By roentgen examination the ureter and kidney pelvis often show, after surgery, hydroureter or hydronephrosis, but before the end of six months or a year this defect has straightened out. The vagina is definitely short, so short that intercourse is interfered with. This compares favorably with the results of roentgen and radium irradiation in the same type of cases. Following irradiation there is atrophy and shrinkage of the vagina and occasionally nearly complete obliteration. It would be hard to choose which of the two was the greater offender.

REVIEW OF 91 RADICAL OPERATIONS

Ninety-one patients were operated upon with no mortality. This, of course, is the most important part of the report. It proves, as does all modern surgery, that formidable operations can be accomplished without a great mortality or morbidity.

Because the classification of the extent of the disease was started before the League of Nations' Classification was in use in our clinic the cases are reported as in the American College of Surgeons' grading. All classification was made before operation and no change was made at the time of or after operation. Table I shows the classification of the tumors and the numbers that have since died and the number of patients with positive lymph nodes found at operation. It is interesting to note that the more advanced the disease, the more died since operation and the more advanced the disease, the more lymph nodes involved. In other words, in this series of cases the preoperative classification was definitely borne out.

Grades of Malignancy. Table II shows that on the whole the prognosis of this tumor is quite satisfactory based upon the type of tumor that is dealt with. The per-

TABLE I

AMERICAN COLLEGE OF SURGEONS' CLASSIFICATION

	No. of Cases	Dead	Positive Nodes
Class A	64	5 or 7.8%	9 or 14%
Class B	23	4 or 17.4%	7 or 30.4%
Class C	4	2 or 50%	2 or 50%

TABLE II

GRADES OF MALIGNANCY

	No. of Cases	Dead	Per Cent
Grade 1	10	1	10
Grade 2	28	5	17
Grade 3	35	4	11
Grade 4	3	0	0
Adenocarcinoma	6	1	16
Adenoacanthoma	2	0	0
? grade	7	0	0
	91	11	

TABLE III

Ages	
15–19	1
20–29	7
30–39	24
40–49	39
50–59	18
60–69	2
	91

centage dead in the Grade 3 tumors is less than that of the Grade 2 tumors by a small and probably insignificant figure. There was a high percentage of lymph node involvement in the adenocarcinoma group. In some cases it was not possible to grade the tumor because the biopsy specimen was too small or because they had had preoperative irradiation and the uterus after its removal prevented proper evaluation.

Ages of Patients. Table III shows that most of the patients fell into the usual age groups for cervical cancer. This tumor is most common between the ages of thirty and sixty, with the greatest number in the decade between forty and forty-nine years.

No Irradiation and Preoperative Irradiation. Fifty-eight, or 63.7 per cent, of the group had no irradiation and in 9, or 15.3 per cent, lymph nodes were found and only 6, or 10.3 per cent, of the non-irradiated group are dead. This contrasts favorably with the group that did have preoperative irradiation. Some of this group had the full dosage before operation but most of them had an amount up to about one-half of the usual roentgen and radium dosage. In the group of 33, or 36.3 per cent of the entire group, 9, or 27.3 per cent, had positive lymph nodes and 5, or 15.2 per cent, of the irradiated group are dead. These figures are higher than for those without irradiation, and yet they fall into the groups with proliferative disease, the irradiation being given to destroy the tumor so that spread of the cancer cells would not take place. The operation was done usually six weeks after the radium was given and in 13 cases no tumor was found in the cervix at operation. This is very satisfactory for tumor cells were not spread at the time of surgery. However, one of these patients is dead of disease and one had positive lymph nodes. It might be asked why operation was done at all and the answer is that if it was known that the disease had been eradicated perhaps a dissection of the lymph nodes would have been all that was necessary but this could not be foretold. Also removal of the parametrium and vagina is an essential part of the operative procedure. Removal of the cervix is a definite reason for doing the operation to carry out proper prophylaxis. Tables IV and V give a more graphic picture of the cases concerned in this study.

TABLE IV

NO IRRADIATION

No. of Cases	58 or 63.7%
Nodes	9 or 15.5%
Fistula	8 or 13.8%
Dead	6 or 10.3%

TABLE V

PREOPERATIVE IRRADIATION

Full or partial irradiation	33—36.3%
Full or partial irradiation with nodes	9—27.3%
Full or partial irradiation with fistula	2— 6%
Full or partial irradiation—dead	5—15.2%

Positive Lymph Nodes. Nodes were found in 18, or 19.7 per cent, of these supposedly early patients and if we admit that irradiation will not cure cancer in lymph nodes these figures are very important and show that starting out with the same group of patients as in this series irradiation would start with a 19.7 per cent deficit. If it is concluded that irradiation might cure cancer in lymph nodes it is unlikely that it would destroy the tumor in all the nodes, especially the obturator region since rays of sufficient strength to kill cancer do not reach this region. Thus it is reasoned that surgery stands a greater chance to cure than does irradiation. Table VI shows the lymph nodes involved and Table VII shows that of the entire group of patients 7, or 38.9 per cent, of the patients are already dead. What the end-results will be is impossible to state, for at least five years should elapse before a proper evaluation can be given. It is true, however, that in the three years postoperative study but 1 patient has died after 2.5 years and that 2 of 7 with positive nodes are living and well, or 28.5 per cent. The usual percentage of five year cure given by Taussig and Bonney in patients with positive nodes is 20 per cent and so far in this series there is indication that it will be about the same. In a large series this salvage of 20 per cent by surgery and no salvage in lymph node cases by irradiation gives surgery a distinct advantage.

Ureterovaginal Fistula. Table VIII shows the incidence of ureteral fistula. The last fistula occurred over two years ago and it is felt that this complication has been eliminated. It is interesting to note that 5 of the 8 fistulae healed spontaneously with the aseptic destruction of the affected kidney. In the patients with healed fistula there have been no recent bouts of infection or indications for removal of the dead kidney. One patient, who had a bilateral nephrostomy, had a huge local tumor and it is doubtful if such a patient would be operated upon as experience has shown that this is not the operative type.

Results of the Entire Group. Table IX shows that of the entire group of 91 cases (six months to over five years) 11, or 12 per cent, of the patients are dead. Two patients who died were autopsied. One was found to have cancer of the stomach, and the other cancer of the lung with no relation to the cervical cancer. No evidence of cervical cancer was found on microscopic examination of the pelvic tissues. If, therefore, these 2 cases are subtracted it makes 9 of 89 patients dead, or 10 per cent. This is very

TABLE VI

Positive nodes	18 or 19.7%
Iliac	9 or 50%
Obturator	11 or 61%
Ureteral	1 or 5.6%

2 cases had iliac and obturator nodes.
1 case had obturator and ureteral nodes.

TABLE VII

POSITIVE NODES

No. of cases	18 or 19.8%
Dead	7 or 38.9%
Living	11 or 61.1%

TABLE VIII

Ureterovaginal fistula	8 or 8.7%
Healed spontaneouly	5
Kidney removed	2
Bilateral nephrostomy	1
Last fistula	May, 1944*

* Date of operation.

TABLE IX

RESULTS

91 cases	Dead 11, or 12%
Minus 2 cases	
Cancer of lung	
Cancer of stomach	
89 cases	Dead 9, or 10%

TABLE X

THREE YEAR RESULTS—36 CASES

Living	28 or 77.7%
Positive nodes	7 (dead—5)
Living—nodes positive	2 of 7, or 28.5%
Living—nodes negative	26 of 29, or 89.6%
*Living—nodes negative	26 of 28, or 92.8%

* Excluding one who died of gastric cancer.

satisfactory so far. Inasmuch as 10 patients died before 2.5 years after operation and as only 1 patient (with positive nodes) died after 2.5 years it is probably true that very few of those living at three years will die of disease at or before five years. Table x gives the three year results of 36 patients; 28, or 77.7 per cent, are living and well; of 7 patients with positive nodes 5 are dead, as was discussed above. Of the patients with negative nodes 26, or 89.6 per cent, are living at three years with little likelihood of any dying at five years; if 1 patient who died of gastric cancer with no evidence of cervical cancer found at autopsy is subtracted, 26 of 28 are living, or 92.8 per cent. These figures are extremely satisfactory. One of the 2 patients in this latter group who died had a tumor so large that it would never be operated upon now and the other had definite paracervical infiltration and this is now a contraindication to operation. It would seem that surgery possessed some advantages over irradiation. It must be acknowledged that this series should be continued until a sufficient number of patients has been operated upon to allow definite five year conclusions to be drawn.

Deaths. The deaths in this series have been tabulated in Table XI and it shows

TABLE XI

DEATHS

Bronchogenic cancer of lung	1
Cancer of stomach	1
Local extension of disease	2
Metastases (nodes)	5
Metastasis to lung	1
Question of cause	1

that distant metastases actually account for a large number of deaths and that those with positive nodes are especially vulnerable. This would also be true in dealing with the radiation treatment of those same patients. If we could avoid surgery in those with distinct lateral extension and those with nodes the results of cure should approximate 100 per cent. Can this be said of irradiation when it is established that there are in certain patients tumors that are radioresistant? Surgery in properly selected patients should and will give at least equally good results as irradiation and in addition the cervix, the source of the disease, has been removed.

CONCLUSIONS

1. A series of 91 cases of radical operation for cancer of the cervix is presented. The length of time after operation is six months to six years.

2. The operative mortality can be kept low as shown by this series and therefore surgery can be compared to irradiation.

3. The one great drawback to surgery, the ureterovaginal fistula, has been overcome.

4. Positive lymph nodes are one of the two great stumbling blocks in radiation therapy and may not be quite so serious in the surgical group.

5. Patients without positive nodes and who are well selected should do extremely well in any surgical series.

6. Radioresistance is the great drawback to radium and roentgen treatment. If a means could be found to establish the fact of radioresistance before treatment is given the results of irradiation and surgery of cervical cancer might be better.*

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* For discussion see page 690.

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THE SURGICAL TREATMENT OF CERVICAL CANCER

WERTHEIM OPERATION; PELVIC LYMPHADENECTOMY*

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WITHIN recent years there has been a renewal of interest in the radical operation (Wertheim operation) for cervical cancer. This interest has been stimulated by some of the drawbacks of radiation therapy, such as late recurrence of the disease many years after treatment, and the not inconsiderable number of distressing irradiation complications which have followed in the wake of the more widespread use of high voltage roentgen therapy. The feeling has grown that cancer cannot recur in a cervix which is no longer present, whereas recurrence is always possible while the cervix remains in situ. The chief disadvantages of the radical operation have been its limited field of usefulness and its relatively high primary mortality. With regard to the former, it is well recognized today that the radical operation is applicable to the earliest cases only, since the spread of cancer beyond the cervix makes the procedure impossible or ineffectual. On the other hand, when the patients have been well selected for surgery and the contraindications have been rigidly observed, the mortality has fallen to such low figures that the procedure is a much more reasonable one than it was in former times.

The second operative procedure which has received some attention in recent years is that of pelvic lymphadenectomy. This operation was first suggested by Taussig in 1930; he employed it in early "inoperable" cases in which he felt that a good local response could be expected, yet death often resulted because of involvement of the regional pelvic lymph nodes. Such involvement was judged to occur in 30 to 40 per cent of cases of the local extent mentioned. Taussig felt that cancer metastases in the regional nodes were peculiarly resistant to irradiation, and that if the nodes could be removed an improvement in results would occur. If this presumption is correct the operation should become much more popular in the future than it has been in the past.

The object of this presentation is to record the experiences obtained with the Wertheim operation and with pelvic lymphadenectomy at the University of California Hospital. The Wertheim operation was first introduced to this institution as a part of the treatment of cervical cancer thirty years ago, by the late Dr. Frank W. Lynch, who remained a staunch advocate of the procedure during his many years as Professor of Obstetrics and Gynecology at the University of California Hospital. However, Lynch viewed its place in cervical cancer therapy as a very restricted one, and he did not advocate its general use because of its many technical difficulties and relatively high mortality. Because of this conservative view the operation has been attempted only 119 times during this entire period, or in approximately 10 per cent of the total number of cases of cervical cancer encountered. Of this number 94 were complete operations and 25 incomplete. By *incomplete* is meant that total removal of the uterus and adnexa, cervix, parametria and upper vagina was not achieved, for a variety of reasons. Occasionally technical difficulties made the complete operation impossible, and at other times, an abbreviated operation was performed by design.

INDICATIONS

The operation has been restricted to those cases in which the cancer was considered to be confined to the cervix at the

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initial pelvic examination (Stage I and II Schmitz), with the exception of 17 cases in which the response to preliminary radium treatment seemed to make an early Stage III growth removable, and 4 cases first treated elsewhere by irradiation (Table I). Further prerequisites have been comparative youth (the average age of the patients was 41.2 years, and very few patients were over 55 years of age), good general condition, the absence of obesity, and good superficial veins, since intravenous infusions of fluid or blood are often necessary to combat shock and hemorrhage. Thus it can be seen that the radical operation has been reserved for the most favorable of the cases. In our complete material we have placed approximately 25 per cent of the cases in Stages I and II. Yet we have operated upon not more than 10 per cent, or less than half of these early cases. In the early days of the operation there existed the greatest diversity of opinion regarding what constituted operability. Franz operated upon 81 per cent of his cases, Stoeckel 70 per cent, Wertheim 46 per cent, Bonney 63 per cent. Since no other effective method of treatment then existed, the operation was attempted in many cases in which at the present time we would regard the growth as too advanced for surgery.

TABLE I

MATERIAL
(Schmitz Classification)

Stage I	35
Stage II	63
Stage III	17
Stage V	4
TOTAL	119
Complete operations: 94	Incomplete: 25

MORTALITY

The differences in operability no doubt account in some measure for the differences in operative mortality between then and now. Operative mortality then ranged from 15 to 20 per cent. Most of the deaths were due to peritonitis or shock. At the other end of the scale is Meigs' recent communication in which he reported *no* deaths in 65 consecutive operations performed during the last few years. At the University of California there have been 6 deaths attributable to operation in 119 cases (Table II). Actually, 3 of the 6 deaths occurred in the first two years of experience, and 4 within the first five years. There have been 2 deaths in the last twenty-five years (101 cases), a mortality rate of approximately 2 per cent. These last two deaths occurred in rather advanced cases in which the patients had received complete irradiation and the growth had been rendered "operable." We now believe *full* irradiation contraindicated as a preliminary to surgery because of the fibrosis and relative avascularity produced in the tissues, conditions which not only complicate the actual removal but which interfere with resistance to infection and healing. There were 17 patients treated in this way; 2 died and almost all of the patients experienced stormy postoperative courses. On the other hand, some preoperative radium irradiation has been employed in 79 cases. The amount has varied according to the response; the object has been to give just enough to cause surface healing and some shrinkage. Amounts varying from 1,500 to 4,000 mg-hr. have been used. Preliminary irradiation of this kind has been adopted as a policy; it is omitted now only in cases in which the growth is very early indeed or in which the vaginal surface of the cervix is relatively clean and intact. It is felt that this preliminary treatment has been largely responsible for the absence of postoperative peritonitis, which has been the chief cause of death in all of the older series.

COMPLICATIONS

Shock has been encountered 21 times. This has been successfully treated by intravenous fluids and transfusions in all instances. Shock has become much less common in the later years of experience. This is

attributable to better anesthesia, better preparation for operation, and to the policy of having fluid running into an ankle vein during the entire operation; in this way blood, which is kept at hand in all cases, can be given at any moment, and usually *is* given as a precautionary measure at some time during the operation.

Injury to the urinary tract has proved to be one of the greatest hazards of the operation. A ureter was accidentally severed in 2 cases. In 1 instance an unsuccessful attempt was made to splice the ureter; eventually the kidney had to be removed because of pyonephrosis. In the other case, the cut ureter was deliberately tied off. The patient made an uneventful recovery. Because of the possibility of this accident intravenous pyelograms are now always obtained preoperatively so that the operator may know the condition of the other kidney.

Urinary fistulae developed postoperatively in 20 cases (16.8 per cent). Ten of the fistulae were vesicovaginal. Two healed spontaneously, 5 were repaired successfully by operation, and 3 persisted (1 patient died of cancer shortly after operation, another will probably die, and the third has a tiny hole which causes her very little inconvenience). There were 7 definite, and 3 questionable ureterovaginal fistulae, of which 8 healed spontaneously and 2 required nephrectomy. The interference with the urinary tract resulted in the loss of kidneys in 4 cases certainly and in 1 case questionably. The urinary fistulae have usually developed some days or weeks after the operation and probably have been due to interference with blood supply. Diligent effort has been made to avoid serious disruption of the ureteral and bladder blood supplies, yet the very nature of the operation has made this difficult. Better preservation of blood supply to the bladder and ureter remains a problem to be solved.

Immediate inability to void has been common due to interference with the sympathetic and parasympathetic nerve supply to the bladder. While this has often proved troublesome, adequate adjustment has been achieved in all cases except one.

Injury to the bowel has occurred much less often. There have been 4 rectovaginal fistulae; 1 followed operation closely and evidently was due to operative injury. This fistula was later repaired successfully. Two of the fistulae developed with the recurrence of cancer, and 1 was due to an irradiation ulcer.

Wound infection has occurred in 21 instances, of which 8 were superficial. There have been no wound disruptions.

Thrombophlebitis, curiously enough, has occurred in 3 cases only.

TABLE II

PRIMARY SURGICAL MORTALITY

1	2/ 1/16	L.	11th day	Pneumonia, local infection, heart failure
2	3/ 1/16	S.	10th day	Pneumonia, heart failure
3	1/30/17	A.	6th day	Peritonitis
4	7/ 9/21	W.	6th day	Myocarditis
5	6/21/34	B.	63d day	Pelvic abscess; cancer
6	8/25/40	K.	58th day	Infection (in irradiated tissue in pelvis)

(Two deaths in the last 25 years; 101 cases.)

RESULTS

There have been a total of 88 cases (through December 31, 1940) treated more than five years ago. Of these, 57 patients have survived the five year period, or 64.7 per cent. It is difficult to arrange a worthwhile comparison of this group with a similar group treated by irradiation, because of the high degree of selection exercised. However, for what it is worth the five and ten year results in Stages I and II cases treated

TABLE III

COMPARISON OF RESULTS BY OPERATION WITH THOSE BY IRRADIATION IN STAGE I AND II CASES
(Through December 31, 1945)

Method of Treatment	Stage (Schmitz)	5 Year Cases	Survived	Per Cent	10 Year Cases	Survived	Per Cent
Operation	I	27	25	92.6	20	18	90.0
	II	46	27	58.7	34	15	44.1
	TOTAL	73	52	71.2	54	33	61.1
Irradiation	I	28	20	71.0	25	11	44.0
	II	65	25	38.5	44	11	25.0
	TOTAL	93	45	48.4	69	22	31.8

by the two methods are compared in tabular form (Table III). Only 3 of the 52 five year survivors treated surgically have subsequently died of cancer at eleven, thirteen and nineteen years respectively (5.7 per cent), while of the 45 five year survivors treated by irradiation, 13 have died of cancer after five years (29 per cent). The survival curve constructed for the ten year cases treated by the two methods (Chart 1) shows graphically the tendency to late recurrence in the irradiated group as compared with results in those operated upon. It would seem that the Wertheim operation has been responsible for "permanent" cure more often than has irradiation, and herein lies its biggest advantage.

In spite of the original theme of the Wertheim operation which aimed to remove not only all of the parametrial connective tissues to which cancer of the cervix is most likely to spread first, but also the regional lymph nodes, which it often invades comparatively early, there is considerable evidence that when these events have occurred the disease is incurable from

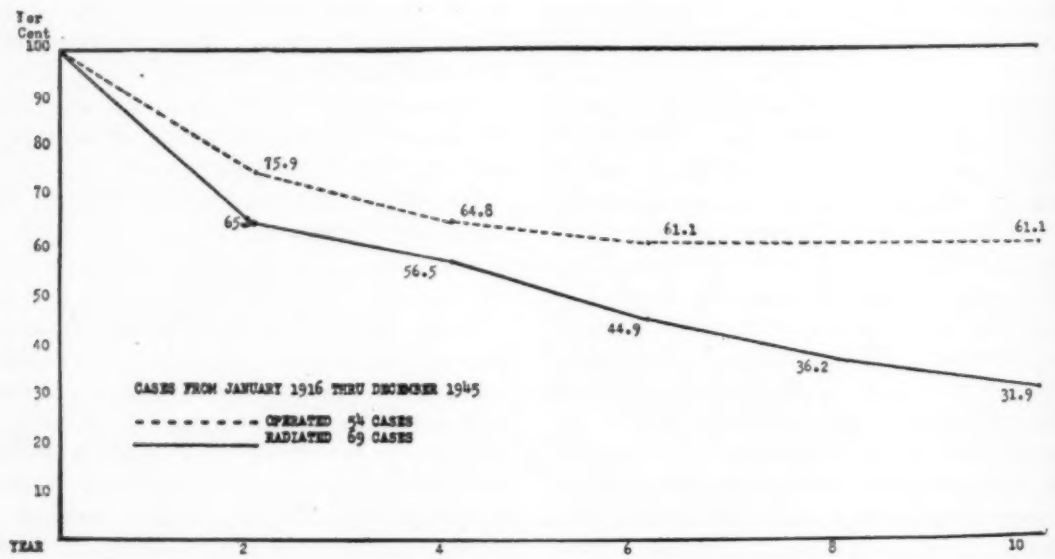

CHART 1. Comparison of results by operation with those by irradiation in Stage I and Stage II. Ten year results.

the surgical point of view. With regard to spread to the parametrium, it has been shown by Martzloff and by Morton that when this has occurred no cures result from operation. The question thus naturally arises—Why the radical (Wertheim) operation; why not an ordinary panhysterectomy? This question cannot be answered with assurance. My own opinion is that the radical operation is superior because it avoids shearing down the sides of the cervix which is a part of the operation of panhysterectomy, and because it removes a portion of the vaginal vault not ordinarily removed in panhysterectomy. Bonney has stated that the operation should remove all or almost all of the vagina to be effective. This may be true of the cases selected by Bonney. So far as we are concerned, we deem a vaginal cuff of 1 to 1½ inches to be quite adequate in the type of case which we select. Since we believe that comparative youth is one of the prime indications for the Wertheim operation, complete removal of the vagina would often prove tragic. As a matter of fact, considerable shortening of the vagina has often resulted from our operations, yet it has rarely been sufficient to do away with a subsequent satisfactory sexual life. This is a matter of great importance and often requires considerable psychological reassurance as well as care and thought at the time of the operation.

With regard to glandular spread, there is no doubt that the removal of involved lymph nodes has sometimes effected cure when the growth has remained confined to the cervix locally; this occurred in 22 per cent of Bonney's cases, and we have had a similar experience with regard to the operation of pelvic lymphadenectomy.

PELVIC LYMPHADENECTOMY

The operation of pelvic lymphadenectomy deserves brief consideration. Taussig's proposition was that in the early inoperable cases (early Stage III Schmitz, Stage II League of Nations), failure of irradiation frequently occurred, not because of the local cervical result which was often good, but because the regional nodes had already been invaded and irradiation failed to eradicate this spread. Upon the supposition that radium and/or roentgen irradiation was incapable of killing cancer when it had spread to the regional nodes, he attempted removal of the susceptible nodes. His results seemed to show an improvement when lymphadenectomy was carried out.

TABLE IV

RESULTS WITH LYMPHADENECTOMY

Total Five Year Cases	42
Survived five year period	30
Number in which involved glands were found	4
Number without involved glands	26
Died in less than five years	12
Number in which involved glands were found	8
Number without involved glands	4

We have tried out Taussig's idea and have not been convinced, though our five year cases are too few to permit conclusions one way or the other (Table IV.) However, by performing this operation we believe that we have learned something of interest and importance.

For years, evidence of the effectiveness of irradiation upon glandular metastases has been lacking. Our results have some bearing upon this question. If we consider all cases in which we have had an opportunity to examine the glands microscopically, obtained at simple lymphadenectomy and also at Wertheim operations, we have had a total of 86 cases (Table V).

Of 51 cases in which the patients had received no preoperative roentgen therapy, regional node metastasis was found in 18, or 35.3 per cent, while of 35 cases in which full roentgen irradiation had been given preoperatively, glandular involvement was found in only 4, or 11.4 per cent. Furthermore there were many more clinically advanced cases in the latter group than in the former. These figures suggest that modern roentgen therapy can and often does de-

stroy cancer in the regional nodes. If this contention could be proved, it would make the operation of lymphadenectomy unnecessary. In 1930, when Taussig started his investigations, the present-day high voltage roentgen therapy was unavailable. It is entirely possible that the techniques then in vogue were inadequate to destroy cancer in the regional nodes, whereas the modern doses may do so.

TABLE V

INCIDENCE OF GLANDULAR INVOLVEMENT IN RELATION TO PREVIOUS ROENTGEN THERAPY

	Cases		Glands Normal	Glands Involved	Per Cent
No preoperative roentgen irradiation	Stage I, II, V	43	32	11	
	Stage III	8	1	7	
	TOTAL	51	33	18	35.3
Had preoperative roentgen irradiation	Stage II, V	5	5	0	
	Stage III	30	26	4	
	TOTAL	35	31	4	11.4

In summary, we may say that we have employed the Wertheim operation in the surgically favorable Stage I and II (Schmitz) cases for thirty years with favorable results. We have operated upon 119 patients, 88 more than five years ago, with a 64.7 per cent five year survival rate, and a primary surgical mortality of 5.08 per cent. We believe that the operation has a place in the treatment of cervical cancer in this restricted group. On the other hand, we believe that irradiation is the treatment of choice in the vast majority of cases at the present time, and furthermore that our experiences in the removal of the regional lymph nodes has given positive evidence that roentgen irradiation is capable of and often does destroy cancer in nodes invaded by metastatic cancer, hence resulting in a survival rate which is 10 to 15 per cent higher than it was with radium alone.

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DISCUSSION OF PAPERS BY DRS. BOWING, FRICKE AND McCLELLAN; KAPLAN AND ROSH; BOUSLOG; WATERMAN, DILEONE AND TRACY; MEIGS; AND MORTON

DR. F. W. O'BRIEN, Boston. This has been an extremely interesting morning, and I would like to congratulate all the essayists. I was particularly interested in Dr. Bouslog's work. Of course, intravaginal radiation is one of the oldest methods of irradiation of the cervix. As early as 1903 intravaginal radiation was used in cancer of the cervix employing a speculum not unlike that described by Erskine in recent years. I would be interested to have Dr. Bouslog give his criteria for using intravaginal radiation.

It was a pleasure to listen to Dr. Waterman, and I think his paper was presented as any paper on the treatment of cancer should be. I do not think we are ever going to properly evaluate any treatment method for cancer unless the absolute cure rate is made the criterion.

I have followed Dr. Meigs' work with interest for many years. I suppose his radium results are as good as any published in the world. In 1939, he was just as enthusiastic about radium as he is now about the Taussig-Wertheim operation. Over 100 cases operated upon without mortality is a surgical triumph. Perhaps when Bonney becomes aware of this he will again take up the Wertheim operation with enthusiasm. Bonney's last paper was based on 500 Wertheim operations. Dr. Meigs' cases are highly selected constituting 10 per cent only of the so-called operable group which, obviously,

is in his favor. If you recall Bonney's last paper, the only good thing he could say for the Wertheim operation was he hoped gynecologists would not forget to teach it to students because it was the best way to obtain a knowledge of the anatomy of the pelvis.

Now, I think Dr. Meigs stated that the roentgenologist starts with a 20 per cent deficit; so does the surgeon. It is not at all certain that supervoltage roentgen irradiation does not sterilize deep nodes but it is certain that surgical removal of nodes does not insure against cancer recurrence. Of course, I am not a surgeon and make no pretense of being one, but I have kept informed as to the indications for surgery and irradiation in the treatment of cancer. I want to compliment Dr. Meigs. He knows full well that he has not been without criticism in his own city. In his enthusiasm and genuine modesty he is apt to forget that there isn't a Joe Meigs every twenty miles throughout the country. We are already seeing patients at my tumor clinic after a so-called Wertheim operation by tyros. If Dr. Meigs will stress in his papers what he has stressed here—that this is a particular operation suitable in a few rigidly selected cases and to be done only by those specially trained—there will be less reason for taking exception to the procedure advocated by him.

Dr. J. A. Corscaden, New York. The general opinion of those treating cancer of the cervix was well expressed in 1937 by Fletcher Shaw: "After careful observation of these cases for over seven years, Professor Dougal and I have come to the definite conclusion that radium offers the best chance of cure as well as being the more humane method of treatment. Therefore, strong advocates though we were of operation, we have now abandoned it."

With improvement in methods of caring for the patient the severe mortality of the operation has been reduced. The net result in cancer therapy will be revealed when there has been sufficient follow up.

According to the statement of Meigs, Morton and Masson, the operation at the present time is suitable for only about 10 per cent of the cases so that irradiation, our only other form of therapy, must be our main support until better methods of diagnosis are developed and in any case in many cases of doubtful operability.

If irradiation is to be employed, a technique should be developed which will deliver adequate tumor doses to all places at which cancer may be expected.

As demonstrated by Nolan and Quimby, most of our methods irradiate the cervix adequately but give inefficient dosage on the lateral walls.

Improvement may be looked for by (1) precision in beaming roentgen rays, abdominal and vaginal; (2) employment of voltages of 800 kv. or more; (3) more efficient disposal of radium both interstitial and intracavity.

By the use of a precision stereoscope, we have been able to place radium needles more accurately in the parametrium, to determine their location accurately and further to measure the distance, and from these measurements, calculate the gamma roentgen dosage. Following this procedure it has been possible to raise the dose in the lateral pelvic region to 7,000–9,000 gamma roentgens.

Dr. A. N. Arneson, St. Louis. The Program Committee for this meeting has arranged one of the most remarkable symposia we have had. Each essayist has presented data pertinent to the treatment of gynecologic cancer. Rather than attempt, at this time, a separate discussion of each paper, it may be worth while to comment upon a point brought rather vividly into view. That point is in reference to the tendency, in some clinics, for using surgery more often and irradiation less frequently in the treatment of more favorable stages of cervical cancer.

Dr. Meigs has mentioned some of the great advances made in surgery. It follows, therefore, that we may expect an improvement in operative results, and extension of surgery to a greater number of patients. Another factor, given by Dr. Meigs as also contributing to greater use of surgery, is the relatively high incidence of sequelae following the application of roentgen rays and radium. There is no doubt that the use of irradiation can result in complications. In his Janeway Lecture, Dr. O'Brien quoted from Dr. Tod in commenting upon the effect of the supralethal dose. Overtreatment can result in an almost unrestrained growth of cancer due to removal of normal inhibitory mechanisms by destruction of the tumor bed. Recognition of those risks in treatment can be considered as one of the advances made in radiation therapy. Further advance may result in correction of these untoward reactions, and

by reducing the incidence of sequelae remove some of the present indications for surgery.

An example can be made of Dr. Waterman's report. He has had one of the most extensive experiences in the use of radium needles. His series of patients is large, and the clinical results are excellent. In some clinics, however, the use of interstitial sources has been found unsatisfactory. Type of clinical material may be a factor, but of equal importance, as pointed out by Dr. Waterman, is the amount of radium per centimeter length of needles. We have employed somewhat lesser strengths than those described, and in clinical practice have not experienced severe reactions.

Considerable advance has been made in specifying tissue dose. The total number of milligram-hours of radium radiation applied to a patient no more indicates the amounts arriving at the tumor and in normal tissues than does the sum of roentgens which may have fallen upon the individual from a roentgen machine. Clinical errors can be made in attempting to transpose techniques on the basis of total doses. When students come for primary instruction at the Gynecological Tumor Clinic of Washington University, they are told that an anticipation of hearing a specification of dosage will meet with disappointment. They are encouraged to think of radium tubes, needles, and roentgen machines as surgical tools to be used only after careful study as to how they should be applied to certain individuals. In planning treatment of a patient the attempt is made to think not in terms of total doses, but in amounts contributed by each source of radium, and every portal used for roentgen rays. If one has tools and principles of treatment identical to those employed elsewhere, then a specified technique can be reproduced. To attempt reproduction without the same armamentarium will require modification of technique.

The one aim shared by all is to improve clinical results regardless of type of treatment employed. One really needs to be present and hear discussions like those presented by Dr. Meigs, Dr. Waterman, and Dr. Morton to comprehend the fundamental procedures involved in the attempt to advance the treatment of cervical cancer, and realize that no debate is involved as to selection of method. Dr. Meigs and Dr. Morton have approached the problem with broad experience already gained. They have advanced radical hysterectomy and iliac lymphadenectomy to the greatest perfection. Those of us who succeeded Dr. Taussig at Barnard Hospital are attempting to continue his work in those procedures, but we have not attained the perfection evident in the reports presented here today. Encouragement should be given the advance in surgery, and dissension presented only that changes in treatment proceed cautiously so that we may best discharge our responsibility to patients. The difficult problems involved in learning the technique of Wertheim hysterectomy have been cited by Dr. Meigs. Extension of surgical care to broader geographical areas should wait until centers such as his have established its value upon the basis of observation of patients for longer periods. The excellent results reported by Dr. Waterman set a high standard for comparison. This does not imply that irradiation need not attempt to advance itself with the same vigor that surgery has progressed.

It has been stimulating to hear this excellent program. I hope both Dr. Meigs and Dr. Morton will return at some later date with another report on their experience.

DR. MAURICE LENZ, New York. The radical operation and lymphadenectomy of pelvic node metastases from epithelioma of the cervix as suggested by Meigs is a difficult procedure and should not be undertaken by the average gynecologist. It should be attempted only by those who through personal experience have learned how to avoid injury to the ureters and other normal structures.

Extirpation may remove cancer within the excised area more securely than irradiation as suggested by Meigs. However, there is no assurance that some cancer cells may not inadvertently be left outside of this area or that the remarkable absence of operative mortality after his operation will apply to similar operations done with less skill.

Lymphadenectomy in experienced hands should be encouraged especially if justified by five year statistics. Treatment of pelvic lymph node metastases by roentgen irradiation or by radium needles or seeds inserted through the vaginal wall has up to now not given a satisfactory five year survival rate. In view of the poor results in neck nodes, secondary to intraoral cancer, it is not likely that the less accessible pelvic nodes will respond more favorably. In parametrial invasion correct dosage of supervoltage roentgen therapy properly spaced will

yield a more homogeneous type of irradiation throughout the pelvis than the locally more intensive yet at the periphery weaker implantation of radium needles or seeds.

In implantation of needles, injury to the ureters and other normal structures is reduced in frequency with greater experience of the operator as shown by the excellent statistics of Waterman and by such attempts at greater precision as carried out in the stereoscopic method of Corscaden *et al.*

Dr. Charles L. Martin, Dallas. First, I want to express my deep appreciation to the essayists for the unusually fine symposium presented here today. Most of you know my enthusiasm for the low intensity radium needles, used by Dr. Waterman, and I believe that his results are among the best that have been published. These needles can be safely placed in the rectum, or bladder, and seldom produce any serious sequelae. It is my impression that he began to observe irradiation damage only after he added roentgen therapy to his radium technique. In our clinic a period of several months is allowed to elapse between the two procedures. Will Dr. Waterman please tell us in closing whether his roentgen therapy is given immediately after the radium application?

Dr. Meigs' work is of unusual interest. Although Dr. Morton's results are promising, I find it difficult to believe that any safe radiological technique will cure carcinoma in the lymph nodes of the pelvis. Certainly, the curative dose for cervical lymph nodes is much larger than the dose needed to eliminate the primary lesion. On the other hand, I am somewhat doubtful of the value of a surgical procedure which removes individual nodes. In the neck only a block dissection is effective, and, in my opinion, Dr. Meigs' operation can hardly be called a block dissection. A study of his operated cases which die of cancer should be of interest. I hope he will tell us, in closing, whether these patients show a local recurrence at autopsy.

Dr. E. C. Ernst, St. Louis. One phase of this discussion perhaps requires clarification, in reference to the postoperative roentgen irradiation effects on the removed metastatic iliac, obturator and ureteral glands in cancer of the cervix. Some of these nodes received insufficient roentgen therapy and the reported effects should not be considered as reliable data in these cases when a total of 800 roentgens was administered.

When larger preliminary doses were administered, and the operative removal was delayed, difficulty was experienced in removing these glands. I know that Dr. Taussig did not wish to leave the general impression that the roentgen irradiation had little effect on these removed nodes. No doubt these studies will be continued at the Barnard Free Skin and Cancer Hospital in view of the more penetrating radiations and other measurements in use today.

Dr. Bowing (closing). This symposium has been most instructive, stimulating and refreshing. The variety of surgical and irradiation techniques and the related data furnish material for comparisons. Evidently the extent of the primary lesion is the feature of the disease which is responsible for the limitations so characteristic in all therapeutic endeavors. The careful selection of patients and the skillful employment of the various techniques presented, either alone or in combination, should definitely improve the immediate and late results. This situation should prove a wonderful stimulus to fine judgment especially when alert consulting staffs are available.

Dr. Meigs emphasized the importance of properly selected cases for his special surgical procedure: Patients must be thin, young and in good health. Furthermore, all patients who have early carcinoma of the uterine cervix are not suitable for his operation. Those who contemplate doing the operation should observe the procedure performed before attempting it. In an early report Dr. Meigs called attention to a distressing feature of the operation, the complications occurring in the urinary tract. These were chiefly due to severing the arteries supplying the ureters. It was fine to learn from him today that these difficulties could be overcome by saving one of these several arterial branches which approach the ureter at a right angle. The three year survival rate was 77.7 per cent and no deaths occurred in the last 90 consecutive cases in which the operation was used. In cases without demonstrable involvement of lymph nodes the survival rate was 82 per cent. These results are very good indeed. Dr. Meigs also reported that 1 patient out of 5 with proved involvement of lymph nodes was saved.

Dr. Morton re-emphasized the fact that only

cases of very early carcinoma of the uterine cervix should be selected for the radical operation (Wertheim). His report covered thirty years of experience. The five year survival rate was 64.7 per cent in 88 cases; his three year survival rate, therefore, would equal the ones reported by others in the symposium. When irradiation alone was employed, the five year survival rate was 31.8 per cent in 93 cases. No doubt this group of patients had more advanced lesions than those treated surgically. Of the surgical cases shock occurred in 21 cases and injury to the ureters in 16.8 per cent. The hospital mortality in the past twenty-five years was 2 per cent. His proof that roentgen therapy will destroy cancer in the regional lymph nodes is convincing.

For comparison the following data are briefly presented. Early experience at the Mayo Clinic is recorded in a study of 1,491 cases. Only 1 patient less than fifty years of age had carcinoma of the cervix, Stage I (international classification) and 27 had carcinoma, Stage II. Of the latter group 9 were between thirty and thirty-nine years of age and 18 cases between forty and forty-nine years. The average age for the entire group was forty-nine years, which indicates that carcinoma of the cervix is a disease of the climacteric. Our three year survival rate was 92.3 per cent in the group of cases of carcinoma, Stage I and 70.4 per cent for the Stage II group. Our five year survival for the Stage I group was 69.2 per cent and for the Stage II group was 60.2 per cent. Radium therapy, followed by roentgen therapy, was employed. There was no hospital mortality in the cases of carcinoma, Stage I and II. We have no record of the morbidity in these two groups; however, our experience indicates this factor would be almost nil, especially if radium therapy was employed. In brief, patients who have carcinoma, Stage I or II, should not receive the customary milligram-hours that are given when a lesion, Stage III, is present.

At the clinic we do not employ intravaginal roentgen irradiation as Dr. Bouslog does; however, his presentation is of great interest.

We do not employ interstitial radium needles as Dr. Waterman does. His report is on twenty years' experience and concerns 579 cases. In about 10 per cent treatment was not given. His five year survival in cases of carcinoma, Stage I (Schmitz) was 78 per cent and in cases of Stage II, 59 per cent. I feel rather certain his three year survival rates would make a favorable comparison. No urinary complications occurred and the hospital mortality was 1.2 per cent in his series.

I am certain all are in agreement with the remarks of Dr. Kaplan and Dr. Rosh in that too many of the cases of carcinoma, Stages III and IV are seen, and surely this number will not be reduced until a broad educational program can be instituted for both the medical profession and the lay people.

The number of cases of early carcinoma presented for review is too small for statistical study, and yet the trends seem clear. It is safe to conclude that these patients can be effectively treated without hospital mortality and with only low morbidity. Our responsibility is very great, indeed, when patients who have early lesions present themselves for consideration.

Personally, I consider it a great honor and privilege to have had a part in the presentation of this splendid symposium.

DR. ROSH (closing). I am very much impressed with today's discussion. But it impresses me as very peculiar that this particular discussion, important as it is, is limited to such a small group of physicians. There should be a greater appeal to see these patients, with cancer of the cervix—to discover them earlier.

There has been an interest aroused in the public by the so-called cancer prevention clinic. We realize that the title "Cancer Prevention Clinic" is not a proper one; that we haven't the right to use that term "prevention." We are trying to see if we can give some different name to these clinics. But it is a fact that the public responds much better to this particular name. It is included in any kind of appeal that the medical profession or different organizations choose to make. In the last several years I have been trying to see if we could establish a prevention clinic in connection with the New York University College of Medicine. During the war this was not possible but now that the war is over I am happy to say that the New York University College of Medicine is planning the establishment of a prevention clinic in the fall. The name is still under question, but the words "cancer prevention" will have to be included in the heading, and it will be established in connection with the university.

I think that is an important step in the right direction, because in this clinic, a clinic of that caliber, we will be able to teach the students from the very beginning to look for the cancer

when it is early. At present we get only a few patients with carcinoma of the cervix Stage I.

Dr. Meigs takes only 10 or 15 per cent of all the cases that come to his clinics. He states that perhaps there are 25 per cent Stage I but he still can operate on only 10 or 15 per cent. At Bellevue Hospital we see patients only in advanced stages. I feel sincerely that if we educate the public in addition to the medical profession to look for and treat those cases early whether by roentgen rays, radium, surgery or in combination, we will all get better results and benefit thereby and that is true in all phases of cancer.

Cancer of the cervix is most accessible when treated early, but still we get mostly Stage III and IV. I feel that we as a unit, as radiologists, have to pull all our efforts towards the possibility of drawing the medical profession into the interesting and important field of discovering and localizing these lesions early, and bringing these patients to the centers where those cases can be properly treated. It is very discouraging to see only advanced cases. Dr. Meigs tells us that he saw three thousand cases with carcinoma of the cervix, most of them were advanced. Since he started to operate on cases of carcinoma of the cervix, he could collect only a hundred cases. Why could he not get more cases? Let them select three thousand cases! Let it all be surgery! What difference does it make? We are interested in results in cures whether it be five years or ten years. There is nothing perfect. Nobody can achieve 100 per cent results, but there is a better chance in achieving a higher percentage of survivals in early stages of cancer than in late.

Dr. Bouslog (closing). I would like to emphasize Dr. Rosh's statement concerning education in cancer. Dr. Rosh has spoken about the education of the physician; I think we have to go back even farther than the physician, namely, to our medical students and medical universities. If you look over the curriculum in most of the universities, cancer is on the sideline. The student is not impressed with the care of these cancer cases. I feel that the diagnosis, treatment and care of these cases should be emphasized in our medical schools more than they are emphasizing them at the present time.

In answering Dr. O'Brien's question about the criteria—when to use the intravaginal or radium therapy—this discussion would require too much time, but I feel there cannot be a set method. Each case has to be individualized and treatment used which in one's judgment is going to give the best result. In the early cases —say, Stage I cases—where the cervix is in the usual midline location, I think radium should be used. In fact, I use radium therapy in these cases. In the more advanced cases where you have involvement possibly of glands—then by using intravaginal therapy you can get the depth dose out into the glands farther than you can with the radium technique, unless you use the technique that Dr. Waterman has suggested, which I am not using. I feel that in the glands—like the obturator glands—you can give more of a depth dose by intravaginal methods than by our previous radiation therapy.

Dr. Waterman (closing). In closing I should like to answer Dr. Charles Martin's question about our use of roentgen irradiation. He has suggested that possibly our complications with roentgen irradiation came from not allowing a long enough interval to elapse between the two types of treatment. I feel quite sure that he is right in this suggestion. When first we began to use roentgen irradiation as part of our planned treatment, we used it right along with the radium, or with practically no interval. We were quite dismayed by many severe reactions in the parametrial, paracervical and especially in the perirectal tissues in back of the cervix, with corresponding rectal and bladder disturbances. These reactions made us hesitant in many cases to use roentgen irradiation in cases where we felt that good results could be expected from past experience without its use. We finally found that by separating the treatments by an interval of two months or more we had far fewer such complications. We now try to protect the center of the pelvis with a lead strip, thereby using the roentgen rays to irradiate the pelvic side walls and outer portion of the parametrium where the radium has least effect.

In answer to Dr. Martin's question about our roentgen-ray dosage, I would say that in our clinic the roentgen therapy is in charge of the Roentgen Department where the therapy is supervised by Dr. Philip Batchelder. He uses two fields, anterior and posterior, 20 cm. in diameter with the lower half of each protected by a vertical strip of lead 4 cm. wide. The usual dose is 2,100 to 2,300 r (measured in air) to each area. Factors: 200 kv., 20 ma., 50 cm. distance, 14 mm.Thoraeus filter.

I have been greatly interested in Dr. Meigs'

work. I have the highest regard for him personally, and for the kind of work he does. I have had the privilege of seeing him do his hysterectomy and he certainly does a beautiful operation. If anyone can get good results with surgery in early cancer of the cervix, I am sure he can and will. In view, however, of the very good results that we have obtained over the last twenty years with radium in these early cases. I have not yet been convinced that we should change our course. Perhaps Dr. Meigs will yet convince us.

In the larger Stage II and some of the Stage III cases, however, it would seem that something besides irradiation were needed. Even if we save 60 per cent of Stage II (Schmitz) cases, we are losing 40 per cent and in Stage III, we are losing 70 per cent, and we lose them because of lymph node involvement in most instances. As Dr. Morton has shown, the larger the growth, the more danger of lymph node involvement. It is very discouraging when from one to three or more years after we have obtained an excellent primary result, with no local recurrence, the patient returns with a pain in her back, thigh or pelvis, and we know that we have failed. More roentgen irradiation, palliation, temporary measures only, put off the fatal outcome. Something must be done about these glands. Present day roentgen techniques have not solved the problem.

I have been much interested recently by a report from Dr. Meigs' clinic in Boston by Drs. Nathanson and Taylor, on a rectoperitoneal approach to the lymph nodes of the pelvis. They did not have a large series to report, but the idea seemed very logical. Some new way must be found to deal with these glands if we are to improve results. Perhaps surgery is the answer.

DR. MEIGS (closing). I feel very humble in the face of all the nice things that have been said. Anything contradictory, I thoroughly understand and appreciate. I do not think this is an experiment. It is something that had to be done because we have so much better surgical techniques now than we have had.

Dr. Nathanson's procedure, as mentioned by Dr. Waterman, is an additional method in the treatment of this disease. We have dissected all femoral and iliac nodes in cancer of the vulva. This procedure is the enlargement of the iliac dissection. In doing this operation Drs. Nathanson, Parsons and Taylor have tried to remove the iliac and obturator nodes retroperitoneally. It is really a very good operation. I think it is better than Dr. Taussig's operation. This operation will be described in detail by Nathanson in the forthcoming book "Progress in Gynecology" published by Grune and Stratton. The one thing missed in this operation is the ureteral node. Dr. Taussig felt that radium and roentgen irradiation would take care of that node. We do both sides and one at a time. Old people stand it much better than the transabdominal approach. Our roentgen department has requested that whenever possible we do lymph node dissections on the patients they are treating. They ask us to do it.

Now, in answer to specific questions. I know we cannot do a block dissection but we do the best we can. The internal iliac region is missed partially. It isn't like a neck dissection. I can do better than I could at first but not as I should like to. Patients die of the distant metastases. Two died of local extension as the cancer was cut across. The cancer was much too large to operate upon and I cut across the tumor and I knew it.

About possible roentgen treatment—in this series of surgical cases we have not used roentgen treatment postoperatively because the whole question is: What can surgery do? After 100 patients have been studied we may easily add it.

DR. MORTON (closing). I would like to add a word or two about the gland resections. You will recall that we had a group of cases in which the patients had received deep roentgen therapy before gland resection, and a group of cases in which preliminary roentgen irradiation had been omitted; and there seemed to be a significant difference in the percentage of patients with involved glands in the two groups. Now, the biggest drawback to these results is that there are not enough cases. If, as the discussion has indicated, others are going to be performing gland resections of one sort or another, it is to be hoped that the findings mentioned will be taken into consideration, and some of the operations will be done after roentgen therapy and some before. In this way a significant number of cases can be accumulated in both categories so that comparisons can be made. It is only in some such way as this that we are going to get some idea as to whether or not roentgen irradiation will actually kill metastatic cancer in glands.

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CARCINOMA OF THE CERVIX

AN APPLICATOR FOR GREATER PARAMETRIAL DOSAGE

By LLOYD A. CAMPBELL, M.D.

SAGINAW, MICHIGAN

A SUCCESSFUL radiation program for the treatment of carcinoma of the cervix should include an internal source of radiation capable of providing a satisfactory dosage to the lateral parametria as well as to the cervix.

The lateral extensions of the carcinoma which often occur early and present no outward evidence of their activity are of the greatest clinical importance. Sandler[7] shows that 50 per cent of the early cases have lymph node involvement. Too often one discovers a recurrence in these areas in cases presumed to be early and in which the usual methods of treatment had been employed. These disappointing clinical experiences may be explained by the fact that radiation dosage reaching the parametria more than 2 cm. lateral to the cervix is, in many techniques, largely contributed by the external roentgen therapy.

To overcome this obvious lack of dosage in these areas many devices have been used and many different techniques employed, all aiming for the same desired result—greater radiation to the parametria. In briefly reviewing the standard radium applicators, one finds the intravaginal cross-arm or "T" applicator rather generally used. This applicator extends laterally a distance of 1.5 cm. from the cervical os and the lateral centers of radiation are often only 2.5 cm. apart. To increase this width Kaplan[3] uses a rubber colpostat, relying upon spring tension and adequate vaginal packing to retain the radium in the vaginal fornices. Kahanpaa[2] has devised a similar spring tension applicator with a more powerful lateral pressure which in favorable cases places the lateral radium sources 6 cm. apart. Schriner[8] has employed a spring and screw device to separate the lateral sources. The Marie Curie, Paris, Stockholm, and Manchester techniques[7] all rely upon multiple vaginal sources (boxes, corks and ovoids) placed high in the vault and fornices to insure a wide cone of irradiation to the parametria. Arneson and Hauptman,[1] Pitts and Waterman,[6] Taylor and Twombly,[9] and others have been using radium needles interstitially into the parametrial tissues. Although these methods contribute to an increased radiation dosage, they carry with them the dangers of infection, fistula, hemorrhage, and thrombosis and for these reasons the interstitial technique has been abandoned by some workers.[9] Merritt[4] has increased the parametrial dosage by the use of intravaginal roentgen radiation directing the lateral ports toward the vaginal fornices. Each technique emphasizes the necessity of dealing with cancer in these areas, even in the early cases, and the effectiveness of any technique is largely related to the dose delivered to the parametrial lymph node regions.

In designing or selecting any applicator for use in the treatment of carcinoma of the cervix one should adhere to certain fundamental requirements. The applicator should provide:

(a) a minimum of danger to the patient from infection, fistula, hemorrhage, thrombosis, and necrosis;
(b) adequate uniform dosage to the cervix and parametria;
(c) simple introduction and removal;
(d) accurate placement of all radiation sources according to the individual needs;
(e) immobilization during use;
(f) a minimum of discomfort to the patient;
(g) a minimum of exposure to the operator during preparation, use, and cleaning;
(h) proper protection to normal structures.

With these requirements in view, I have

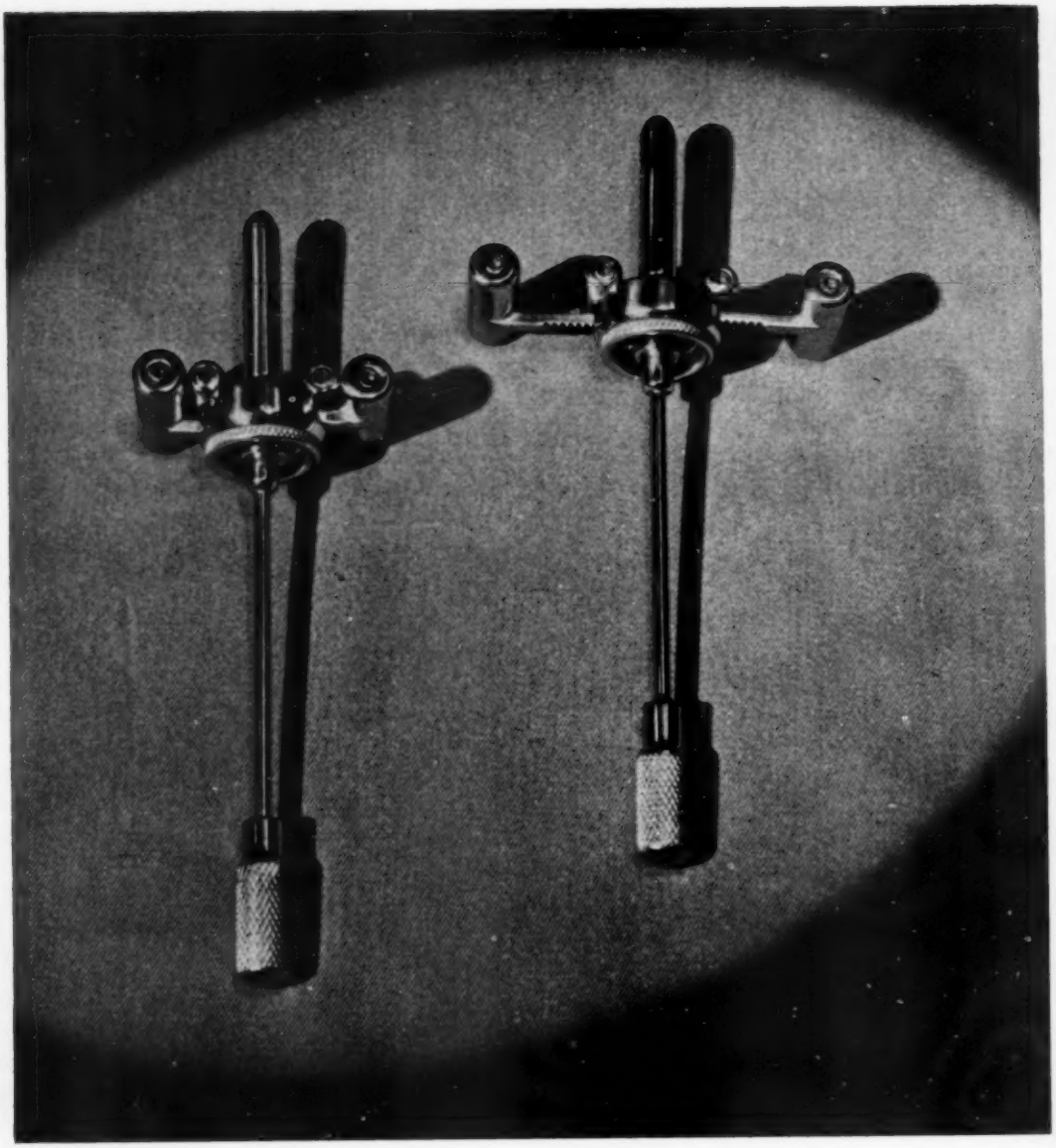

FIG. 1. Applicators closed (5 cm.) and open (7.5 cm.) showing positions of the lateral capsules.

constructed an intravaginal radium applicator made entirely of brass to be used with standard platinum cells as sources, although with slight modification other sources may be used. This applicator consists of a circular body to which is attached the cervical tandem and two stationary capsules placed 2.5 cm. apart. These capsules are 1.8 cm. in length with a diameter of 0.75 cm. and, like the tandem, have a filter equivalent to 1.0 mm. of platinum. The placing of the stationary capsules 2.5 cm. apart contributes to the dosage given to the cervix in a manner similar to that of the colpostats or other multiple sources as used in several of the established techniques. Within the body of the applicator is located a cam which actuates dual racks or lateral arms to each of which is fixed a capsule or radium source. These capsules are 2.5 cm. in length with a diameter of 1.0 cm. and have a filter equivalent to 1.5 mm. of platinum. By the rotation of the cam, these capsules can be extended laterally any dis-

tance up to 7.5 cm. in total width. By the use of this mechanical principle the capsules are held in any position in which they are placed and this can only be changed by a subsequent rotation of the cam. Connected to the cam is the handle which serves as an introducer as well as the means to provide rotation. The handle is removable for cleaning but in use is left in place to facilitate an easy withdrawal of the entire applicator. When the applicator is closed for introduction or removal, it extends 5 cm. in width and 2.5 cm. in the anteroposterior diameter.

No special technique is needed to introduce the applicator. An introitus and vaginal tube of sufficient size is the only requirement for its employment, since difficulty may be encountered in nullipara and in elderly persons with an atrophied vaginal tract. It is also apparent that a satisfactory parametrial dosage is dependent upon the size and the degree of distensibility of the vaginal vault. In approximately 70 per cent of the cases no difficulty was encountered in obtaining the maximum width of 7.5 cm. In other cases the position of the cervix, size and position of the tumor, and the induration of the parametria prevented the maximum advancement of the lateral capsules. Occasionally one encounters a stenosed vaginal vault after a course of external radiation therapy if too long an interval has elapsed. In these cases the quantity of the radiating sources can be distributed among the four intravaginal capsules to give each area its maximum dosage.

In the preparation of this instrument the entire body and racks are given a copious

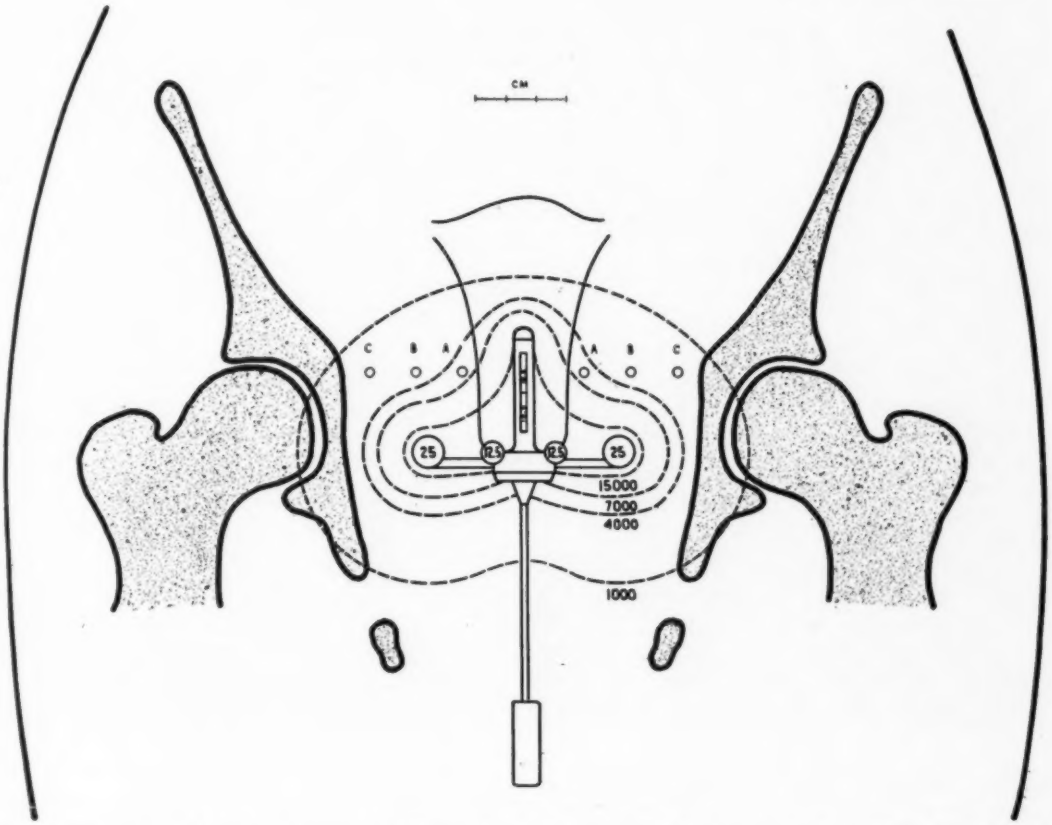

Fig. 2. Distribution of radium sources in the tandem and capsules of an open applicator in a normal pelvis. The dotted lines show the tissue gamma roentgens delivered by all radium sources. One thousand gamma roentgens are approximately equal to one threshold erythema dose. The circles lateral to the internal os at *A* (2 cm.), *B* (3.5 cm.), and *C* (5 cm.) are the points of comparison in Table 1.

application of vaseline to prevent blood clotting around the cam during its use and to facilitate introduction and removal. Upon introducing the tandem into the cervix the entire applicator is then located high in the vault of the vagina and the observation. A perineal pad and "T" binder can be snugly placed over the end of the handle since it projects slightly from the vaginal orifice, further immobilizing the applicator and preventing its descent from the original position.

TABLE I

DOSES (IN R_γ) AT CERTAIN DISTANCES LATERAL TO MID-LINE OF TANDEM IN TRANSVERSE PLANE THROUGH INTERNAL OS

Technic	Calculator	Mg.-Hr. Exposure	Distance		
			2 Cm.	3.5 Cm.	5 Cm.
TANDEMS WITH INTRAVAGINAL SOURCES					
Arneson	Nolan and Quimby	5,000	7,000	3,500	1,000
Stockholm	Tod and Meredith	8,000	5,400	—	1,800
Marie Curie	Sandler	5,280	—	3,000	1,680
Paris	Sandler	7,200	—	4,500	2,250
Paris	Tod and Meredith	8,000	6,150	—	2,500
Manchester	Tod and Meredith	6,600	7,200	—	2,400
Manchester	Sandler	11,000*	—	7,000	4,250
TANDEMS WITH INTERSTITIAL SOURCES					
Arneson and Hauptman (Fig. 1, Arrangement III)	Nolan and Quimby	6,100	10,000	4,000	1,000
Pitts and Waterman (Fig. 11, Arrangement V)	Nolan and Quimby	8,000	15,000	6,500	3,000
Teahan, Wommack, and Weatherwax	Nolan and Quimby	11,500	—	7,500	4,000
Reinhard, Goltz, and Schreiner†	Reinhard	6,000	7,300	3,000	1,500
Nolan and Quimby (Arrangement VII)	Nolan and Quimby	6,600	11,000	6,800	2,500
Nolan and Quimby (Fig. 111, Arrangement VIII)	Nolan and Quimby	8,000	12,000	7,200	3,000
TANDEM WITH INTRAVAGINAL SOURCES					
Campbell	Campbell	7,200	5,970	3,990	2,500

* Two sets of treatments, 3 weeks apart.
† Tandem with interstitial radon seeds.
(Table reproduced by permission from Nolan and Quimby [5])

handle rotated clockwise to extend the lateral capsules. The amount of rotation necessary can be readily determined by the countertension exerted by the pelvic tissues. Inspection and palpation of the vaginal walls during the progress of introduction will prevent any unnecessary trauma. Once accurately placed there is no change in the position of the applicator during the treatment. A vaginal pack is used to displace the bladder and rectum from the effects of the central radium source and no unusual rectal symptoms have been encountered during the period of clinical

The question of dosage should be individualized for each lesion and the distribution of the radium among the four vaginal capsules and the tandem should be apportioned to meet each specific need. If one can obtain a satisfactory lateral extension of the capsules to the pelvic walls, these sources may be regarded as added radiation, contributing to a larger total dosage. Usually the radium sources are divided as shown in Figure 2, giving a total of 100 milligrams in the applicator. A total dose of 7,200 mg-hr. is administered in two applications of thirty-six hours each with a

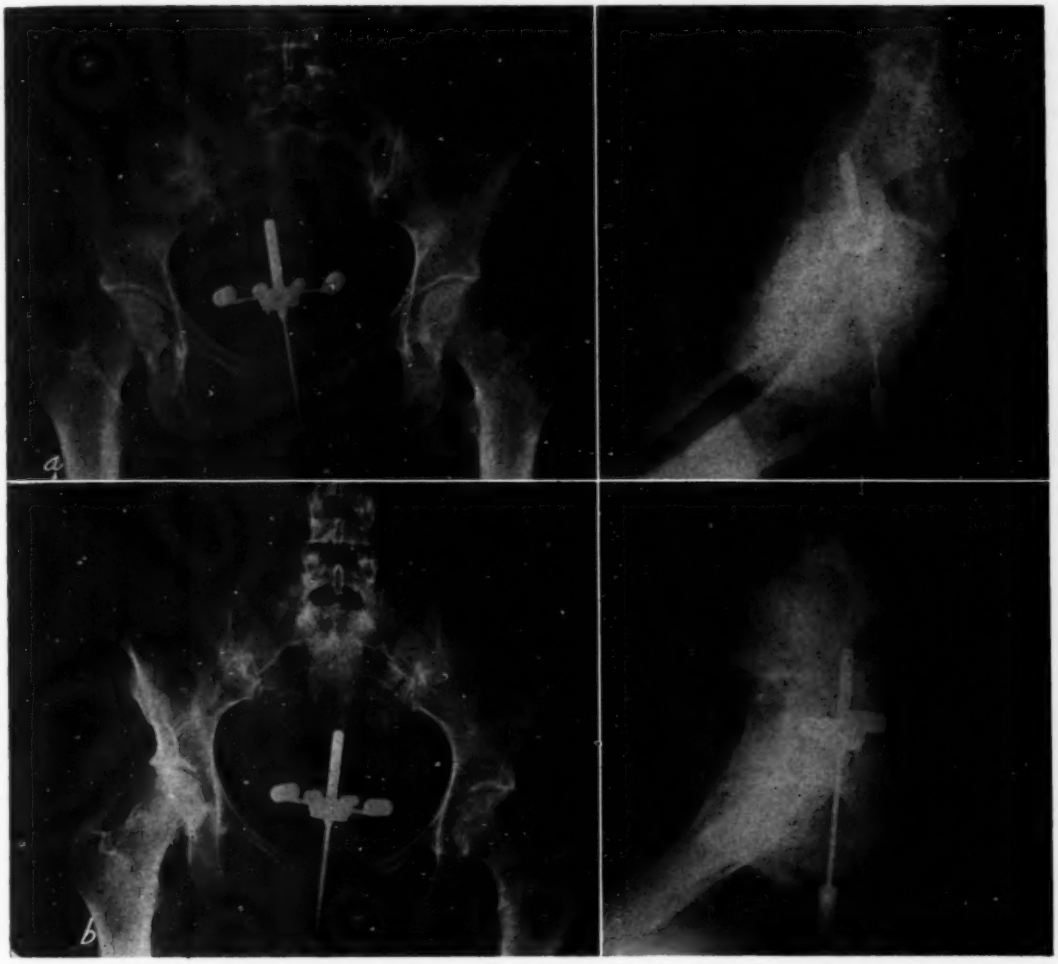

FIG. 3. Anteroposterior and lateral roentgenograms of typical cases of carcinoma of the cervix in patients thirty-three (*a*) and twenty-five (*b*) years of age showing the extended applicator in position.

four day interval. This may be considered as a basic procedure which is subject to many variations, depending upon the anatomical requirements and the clinical findings of each individual patient. The isodose curves in Figure 2 show the areas included for 15,000, 7,000, 4,000, and 1,000 gamma roentgens. The three areas of importance in lymphatic drainage are indicated as *A*, *B*, and *C*. Any methods of therapy which deliver less than 6 threshold erythema doses to a point 5 cm. lateral to the internal os at *C* will fail to control the disease in the majority of cases. In order to compare the various methods of interstitial implantations with those of intracervical tandems with intravaginal sources, Nolan and Quimby[5] have prepared Table 1. Below this table, I have given the calculations for this applicator, which are 5,970 gamma roentgens at 2 cm. (*A*), 3,990 gamma roentgens at 3.5 cm. (*B*), and 2,500 gamma roentgens at 5 cm. (*C*). This would provide 2.5 T.E.D. to the lateral parametrial areas which together with adequate external radiation will closely approximate the 6 T.E.D. necessary to control the disease. While the nodes at *C* are receiving this dose, the area of limiting tolerance (paracervical triangle of Tod)[10] 2 cm. lateral to the internal os at *A* is well within the margin of safety.

A particular advantage which this ap-

plicator provides by its rigid construction is its ability to deliver an exact and constant dose which does not depend upon such variables as the pressure with which the packing is applied, the stiffness of springs, or other uncontrollable factors.

The cases in which this applicator has been used have been followed for much too short a time to give an adequate comparison with the results obtained by other methods. However, its simplicity and accuracy of placement, its absolute immobilization, and the greater parametrial dosage which it provides all contribute to a more successful program in the treatment of carcinoma of the cervix.

The author wishes to express his gratitude to Dr. Edith H. Quimby for checking his calculations for points *A*, *B*, and *C*.

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EFFICIENT DEEP TUMOR IRRADIATION WITH ROENTGEN RAYS OF SEVERAL MILLION VOLTS

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THE aim of radiation therapy is to secure the complete destruction of malignant neoplasm while causing only a tolerable injury to the skin and surrounding normal tissue. All of the radiation therapy developments of the past fifty years since Röntgen's discovery are seen to be directed toward this objective. The use of penetrating gamma rays in beam and interstitial radiotherapy, the tendency toward higher voltages in roentgen-ray therapy, the investigation of the efficacy of neutron beams, the study of the ionization distribution of high energy cathode rays, and finally the treatment of localized tumors by the selective absorption of artificially radioactive substances—all seek primarily to improve the effectiveness with which the tumor is subjected to the cellucidal effect of high energy radiation.

External radiation sources such as roentgen rays are undoubtedly the more general approach to the deep therapy problem in that a beam of the required aperture and intensity can be directed toward any desired region. Such therapy, however, has suffered in the past from the limitation that the beam must enter through the relatively radiosensitive skin and undergo very considerable attenuation and misdirection by the absorption and scattering processes before it reaches the region of a deep tumor. Many of these difficulties are reduced by ingenious choice of treatment distance, field size, the number of portals through which the radiation is directed, and the fractionation technique. More often than not, however, in the treatment of deep-seated malignancies with presently available radiation, the total dose and daily dose are established not by the optimum amounts needed to destroy the tumor, but rather by the limitations of surrounding normal tissue or the tolerance of the skin through which the radiation passes.

The developing availability of roentgen rays with energies of several million volts makes possible a great increase in the efficiency with which radiation can be brought to bear on such underlying tumors. This paper discusses the characteristics of roentgen rays produced by constant potentials of from 1 to 4 million volts with special emphasis on 2 million volt radiation, describes the "subcutaneous effect" of such higher energy roentgen rays which results in low skin dose, and illustrates techniques of beam aperture, treatment distance, and cross-firing which make possible deep tumor doses several times higher than those sustained by the skin or even tumor adjacent tissue.

THE ROENTGEN- AND GAMMA-RAY SPECTRA

It is appropriate to consider again the characteristics of the radiation produced when the energy of the target-impinging electrons is homogeneous and in the several million volt range.

Those occasional electrons which lose all of their energy in a single encounter with an atom of the target produce a pulse or photon of radiant energy of the shortest wave length possible for that voltage.[1] The wave length of such photons is beautifully and precisely given by the Planck-Einstein relation

$$eV = hc/\lambda_0$$

where e is the charge of an electron, V is the acceleration voltage, h is Planck's constant, c is the velocity of light, and λ_0 is the wave length of the emitted radiation. For 1 million volt roentgen rays, this shortest wave length λ_0 is 0.0124 Å, and for 2 million volts it is 0.0062 Å where an Ångström is 10^{-8} cm.

Most of the electrons, however, lose their energy in a succession of collisions with target atoms so that a continuous spectrum of ionizing radiation is produced. Such roentgen-ray spectra, calculated according to Kramers'[2] formula, are shown in Figure 1 for 3, 2, 1, and 0.5 million volt electrons. A distinctive feature of the continuous spectrum is the intensity peak found at wave lengths about 40 per cent longer than

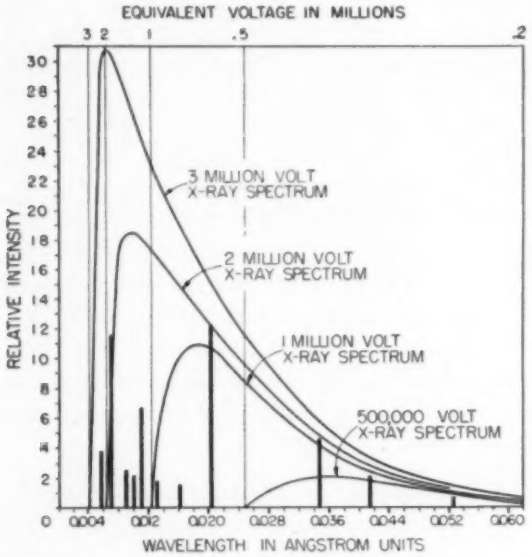
EQUIVALENT VOLTAGE IN MILLIONS
3 2 1 .5 .2
RELATIVE INTENSITY
30 28 26 24 22 20 18 16 14 12 10 8 6 4 2 0
3 MILLION VOLT X-RAY SPECTRUM
2 MILLION VOLT X-RAY SPECTRUM
1 MILLION VOLT X-RAY SPECTRUM
500,000 VOLT X-RAY SPECTRUM
0.004 0.012 0.020 0.028 0.036 0.044 0.052 0.060
WAVELENGTH IN ANGSTROM UNITS

FIG. 1. Comparison of the continuous roentgen-ray spectrum produced by 3 million, 2 million, and 1 million, and 500,000 volt electrons with the gamma-ray line spectrum emitted by radium in equilibrium with its products.

the minimum wave length. Evidently the wave length of maximum intensity corresponds to the most probable amount of energy lost in these electron-atom collisions. At still longer wave lengths the intensity diminishes, some intensity being produced throughout the regions of soft roentgen rays and ultraviolet light, though these components are mostly absorbed by the target before they emerge. Very little radiation with energy less than 200 kilovolts escapes absorption by the target and filters normally used with roentgen rays of 1 million volts or higher.

The effect of increasing voltage on the continuous roentgen-ray spectrum is to move it progressively in the direction of shorter wave lengths and to increase the total radiant energy produced by a given number of watts on the target. As the wave length diminishes, the ability of roentgen rays to penetrate through matter increases because of the progressive reduction of both the photoelectric and the Compton scattering processes of absorption. For roentgen rays produced by a few million volts the "pair production" absorption mechanism is still unimportant—particularly for tissue-like absorbing material. Radiation produced by 2 million volt electrons and filtered by a few millimeters of lead is closely equivalent in penetrating power to the gamma rays emitted from radium in equilibrium with its products. For comparison, such a gamma-ray line spectrum is included in Figure 1.

SPATIAL DISTRIBUTION OF ROENTGEN RAYS ABOUT THE TARGET

The heterogeneous radiation spectrum produced at the target is not emitted uniformly in all directions. As seen in Figure 2, the roentgen-ray emission for the lower

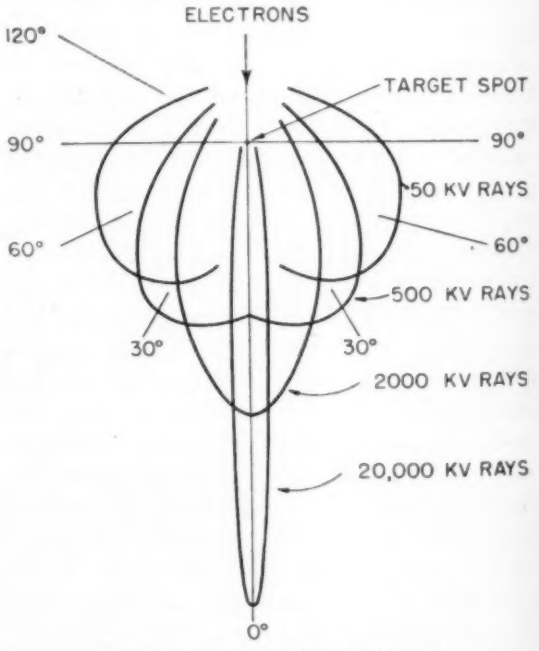

FIG. 2. Spatial intensity distribution of roentgen rays about the target as a function of the voltage of the impinging electrons.

voltages is most intense in the directions almost transverse to the electron stream;[1] for 500 kilovolts the greatest roentgen-ray intensity is in the direction of the sides of a 40° forward-directed cone;[3] at 2 million volts the radiation proceeds in a broad beam with maximum intensity directly forward and with half-intensity values at about 30° from the electron axis;[4] by 20 million volts the beam has become a narrow pencil of rays with but 9° of total angle between half-intensity values.

The relative absorbability of roentgen rays of 200 kilovolts and below and their spatial distribution about the target necessitate the use of the reflected transverse-directed radiation. For roentgen rays produced by more than one-half million volts, the spatial distribution accounts for the desirability of using the forward-directed beam transmitted through the target. The increasing difficulty because of diminishing beam width of uniformly irradiating any considerable area with roentgen rays of 20 million volts or more is evident.

THE SUBCUTANEOUS EFFECT

When roentgen rays produced by several million volts are incident on a tissue-like material, energy is absorbed primarily by the Compton process, and electrons are accelerated. These high energy Compton electrons accompany the roentgen-ray beam forward into the interior of the absorbing material, producing by collision thousands of low energy electrons along their path. The biological effect of the radiation at any point is proportional to the density of these secondary electrons.

This ionization density increases in the first short distance within the absorber as more and more electrons are accelerated to join the advancing beam. The maximum ionization is reached at that distance below the surface at which the first Compton electrons have on the average expended their energy in ionization and stopped. For 2 million volt radiation the average forward range of the Compton electrons is about 3 mm. This average range increases fairly linearly with voltage, becoming about 3 cm. with 20 million volt radiation. Beyond the depth of maximum ionization the ion density proceeds to diminish because of reduction in the roentgen-ray beam intensity by absorption, scattering, and divergence.

Thus, the ionization produced by supervoltage roentgen-ray beams does not reach its maximum value immediately at the surface as is substantially the case with roentgen rays of 200 kilovolts and below, but increases to maximum intensity at a distance below the surface which corresponds closely to the average range of the forward-directed secondary electrons. This maximum intensity at a depth, which has been termed the "subcutaneous effect,"[5] is an important factor in explaining the impressive increase in erythema dose with voltage reported by experimenters with supervoltage roentgen rays.[6,7]

DEPTH DOSE AND SCATTERING

A further effect of increasing the roentgen-ray voltage into the million volt range is to reduce the scattering and absorption of the radiation. At 200 kilovolts and below, the scattered energy is predominantly softer roentgen rays which have a considerable range in air and tissue; above 1 million volts the scattered energy is predominantly electrons which have a relatively limited range. Thus, while back-scattering at 200 kilovolts amounts to 36 per cent of the incident radiation, back-scattering is reduced to 7 per cent at 1 million volts and about 3 per cent at 2 million. Evidently both back-scattering and the closely corresponding side-scattering have diminished to relatively negligible amounts for roentgen rays of a few million volts' energy. This diminished side-scattering and lower absorption of the direct beam accounts for the higher depth dose which may be secured. For treatment with a 10 by 10 cm. field at 1 meter distance the 10 cm. depth dose increases from 35 per cent for 200 kilovolt filtered radiation to 46 per cent for 1 million, 52 per cent for 2 million, 57

per cent for 3 million volts, and 61 per cent for 4 million volts.[5]

EXIT DOSE WITH SUPERVOLTAGE RADIATION

Fortunately the exit dose produced by roentgen rays of several million volts can still be reduced satisfactorily by the combination of absorption and the inverse-square law. With 1 meter treatment distance the 20 cm. exit dose for 200 kilovolt radiation with a 10 by 10 cm. field is about 11 per cent. When a 2 million volt roentgen-ray beam has traversed 20 cm. of tissue, the intensity has reduced to 22 per cent of its maximum value; for 3 million volt rays the 20 cm. exit dose is 28 per cent of the maximum.[5] These values are still sufficiently small to avoid adverse skin reactions at the beam exit.

Roentgen rays produced by voltages much higher than a few million have exit dose values which approach undesirable levels. With 20 million volt radiation, for example, the 20 cm. exit dose at a 1 meter treatment distance is over 65 per cent of the maximum.[8] Shorter treatment distances have been recommended for such elevated voltages so as to reduce the exit dose by the reason of the inverse-square law. Reduced treatment distance, however, increases the non-uniformity with which a given field size can be irradiated by the narrow beam characteristic of such voltages.

ELECTROSTATIC ROENTGEN-RAY GENERATOR AND MEASURING EQUIPMENT

The constant potential roentgen rays used in this work were produced by the pressure-insulated electrostatic generator[5] of the Van de Graaff type constructed some years ago at the Massachusetts Institute of Technology. Roentgen-ray sources of this type possess the ability to produce steady continuous streams of electrons, homogenenous in energy, and controllable over a wide voltage range. In this apparatus the voltage range, which could be carefully studied, ranged from one-half to 4 million volts. The electrons were incident on a water-cooled gold target 4 mm. in thickness; the roentgen rays transmitted through the target in the direction of the electron stream were used in this work and were defined into a beam by a suitable lead diaphragm system. It is desirable that this beam-defining lead portal be located some distance away from the skin so that secondary electrons produced at this portal will be considerably scattered and absorbed before they reach the skin. A satisfactory arrangement for a treatment distance of 1 meter is obtained by locating the bottom surface of the beam-defining portal not much more than 50 cm. from the target.

The distribution of ionization produced by roentgen-ray beams was measured in a phantom of Masonite presdwood having the average density of 1.02. This phantom was mounted on a remote-controlled carriage so that the special ionization chamber imbedded at the desired level in the phantom was caused to move across the stationary beam. A similar but independent ionization chamber was used as the control in a fixed position at the center of the beam and just above the phantom surface. The active volume of the thimble chamber itself was 0.5 cm. in diameter by 3 cm. in length. The measuring circuit included a Victoreen three-element electrometer tube in a simple electrometer circuit, the tube and storage condensers being located in the radiation room close to the phantom, but out of the direct beam and shielded by 1 inch of lead. The output plate current microammeter was located at the operator's position.

2 MILLION VOLT ISODOSE CHARTS

Figures 3 and 4 are isodose charts for 2 million volt constant potential roentgen rays filtered by the equivalent of 9 mm. Pb. The target-to-phantom distance is 100 cm. and the field sizes are 10 by 10 cm. and 5 by 5 cm. respectively. It is seen that these charts differ from those obtained with 200 kilovolt roentgen rays in that the maximum roentgen-ray intensity is found a well

defined distance below the skin surface, while the beam itself possesses a higher fraction of its maximum intensity at the 10 cm. depth with little tendency toward side-scattering. With the 10 by 10 cm. field the 10 cm. depth dose under the above conditions is over 50 per cent and remains uniform across the effective area of the beam. The rather small 5 by 5 cm. field, which would be relatively more affected by side-scattering, delivers a fairly uniform irradiation at the 10 cm. depth with an average depth dose value well over 40 per cent.

The effect on the isodose curves of the ionization chamber diameter and of the discrete steps with which the phantom was moved across the beam is to produce an apparent broadening of the beam edges. That these edges are actually more sharply defined than the measured value in Figure 4 can be seen by comparison with the photographic equivalent in Figure 7.

Thus 2 million volt radiation in contrast

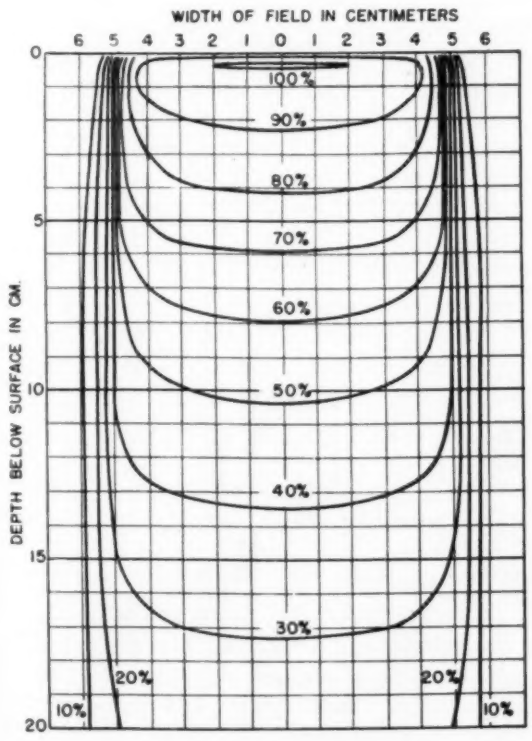

Fig. 3. Isodose chart for 2 million volt constant potential roentgen rays, 100 cm. distance, 10 by 10 cm. field, 9 mm. Pb equivalent filtration.

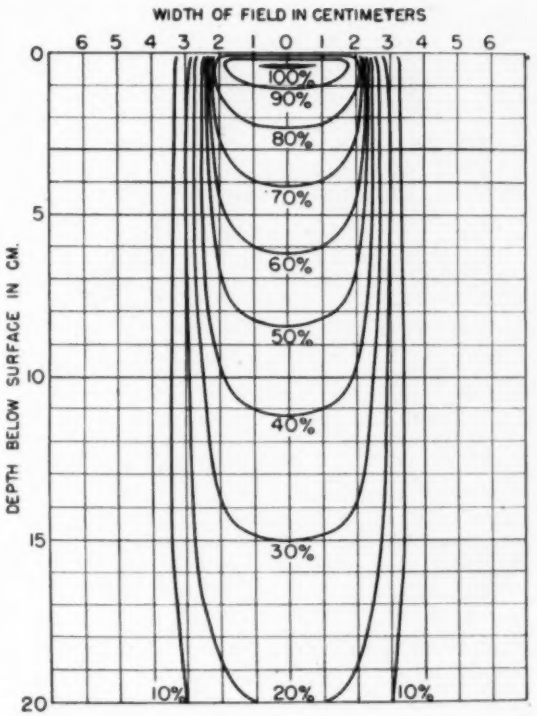

Fig. 4. Isodose chart for 2 million volt constant potential roentgen rays, 100 cm. distance, 5 by 5 cm. field, 9 mm. Pb equivalent filtration.

to 200 kilovolt radiation is characterized by low intensity in the radiosensitive region of the skin at the portal of entry, shows a pronounced tendency to remain directed as a beam with uniform irradiation of the field area, and delivers a relatively high depth dose with tolerable values of exit dose. Such high energy radiation possesses to a degree hitherto unavailable the desirable characteristics of greater penetration and smaller scattering for the effective radiation of regions at a depth.

CROSS-FIRING WITH 2 MILLION VOLT RADIATION

The advantageous distribution of tissue ionization produced by roentgen rays of several million volts' energy should make possible improved clinical procedures and results. In many cases such rays would permit deep tumor irradiation with a single beam which is comparable and perhaps even superior to that attained with multi-

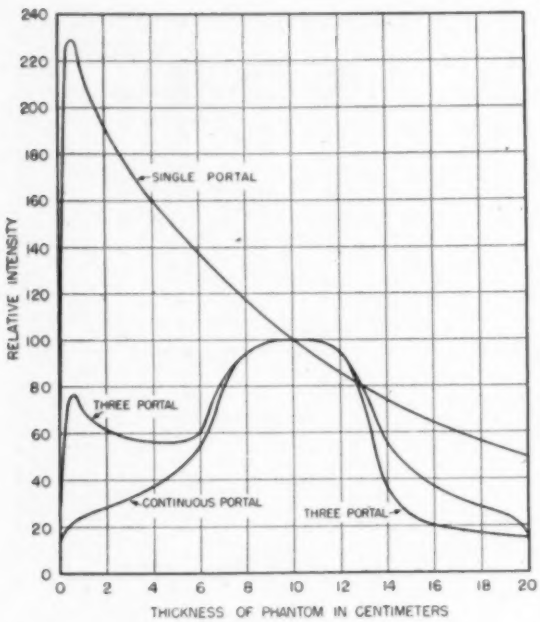

FIG. 5. Distribution of ionization produced in single portal, three portal, and continuous portal irradiation with 2 million volt roentgen rays. A 20 cm. cylindrical phantom, 5 by 5 cm. field, and 100 cm. distance were used.

portal irradiation using 200 kilovolt rays. Depending on the shape and location of the region to be treated, the situation may occur where a single portal treatment with this penetrating radiation is the preferred procedure.

As would be anticipated, however, the combination of a more penetrating, less scattering, and skin favoring radiation also lends itself to a more effective cross-firing technique. When this technique is properly applied, the unusual result may be obtained in which the delivered tumor dose is quite uniform throughout any desired volume at a depth, and considerably higher than the dose received by the skin either at the entrance or the exit portals.

Figure 5 shows the distribution of dose through a cylindrical phantom 20 cm. in diameter irradiated by a 2 million volt beam with a 5 by 5 cm. field at the skin. The target-to-phantom distance is 100 cm. and the filter is 9 mm. Pb equivalent. The curves show the ionization distribution along the beam axis for the cases of a single portal irradiation, three portal irradiation, and continuous irradiation obtained either by rotating the phantom or rotating the tumor-directed beam with phantom stationary. The single portal case was measured directly with suitable ionization chambers; the multiportal cases were calculated from the isodose curve of Figure 4. While this illustration is evidently idealized with respect to the actual problem confronting the radiologist, it has been so chosen in order to show more clearly the possibilities of efficient deep tumor irradiation.

It is seen that for three portal and continuous irradiation, the level of intensity varies by only a few per cent across the tumor area and throughout the volume of the tumor as defined by the chosen aperture of the beam. In the case of continuous cross-firing, the skin dose begins at but 16 per cent of the tumor dose; even 5 cm. below the skin and less than 4 cm. from the designated tumor region the dosage is less than 50 per cent of the tumor dose. The prospect of avoiding serious damage to radiosensitive organs close to a known tumor site is evident.

Figure 6 contrasts 200 kilovolt and 2,000 kilovolt radiation in three portal cross-firing. Published data for the commonly

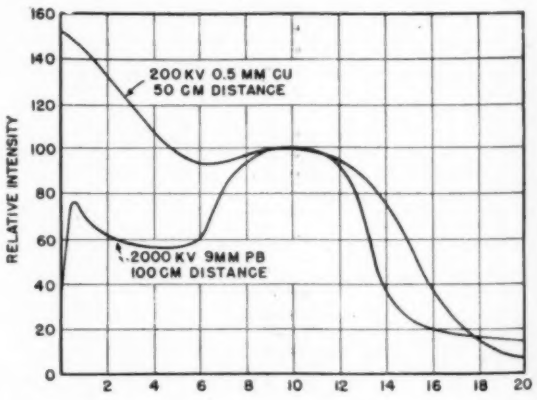

FIG. 6. Comparison of three portal cross-firing with filtered 200 kv. and 2 million volt radiation. Curve shows the ionization density along one beam axis for three portal cross-firing into a 20 cm. cylindrical phantom. The beams are 5 by 5 cm. at the surface. The values are calculated from single portal isodose measurements.

used treatment distance of 50 cm. were employed in the 200 kilovolt calculation. The 200 kilovolt radiation is considerably less favorable because of the relatively high dose received by the skin and the region between skin and tumor.

Figures 7, 8, and 9 illustrate photographically the distribution of ionization

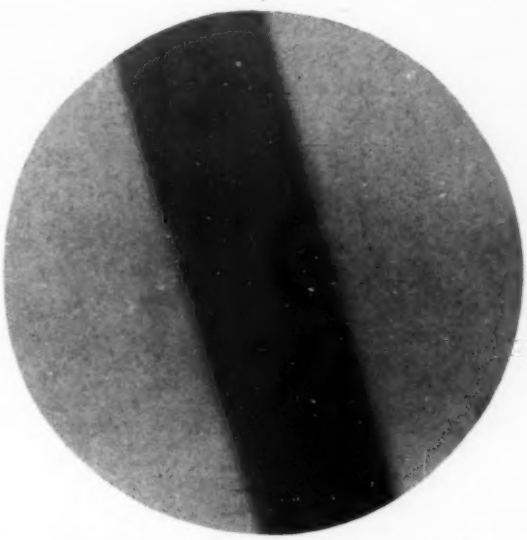

Fig. 7. Two million volt beam passing through a 20 cm. diameter Masonite phantom. Target-to-phantom distance 100 cm., beam size at surface 5 by 5 cm.

obtained under the above described conditions with 2 million volt roentgen-ray beams for the single portal, three portal, and continuous portal cases. These exposures were made with the film sandwiched between halves of the cylindrical phantom split in the transverse plane. The density variations in these figures correspond closely to the more quantitative ionization measurements given in Figure 5. The freedom from scattering, the uniform density across the beam, and the relative effectiveness of cross-firing are revealed. For effective irradiation of a given tumor site, the beam aperture should be chosen so as to provide a relatively uniform tumor dose with appropriate overlap into the adjacent region to account for uncertainties as to the tumor boundary. This would in general be achieved with a projected field size at the tumor slightly greater than the tumor size.

One may conclude from Figure 5 that multiportal irradiation is sufficiently fa-

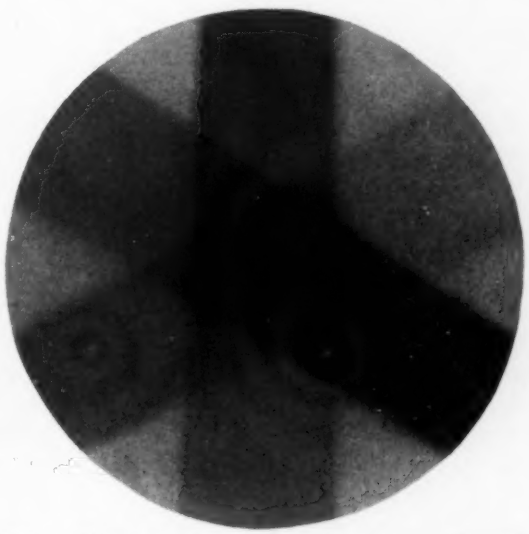

Fig. 8. Three portal cross-firing into 20 cm. diameter phantom. Other conditions as in Figure 7.

Fig. 9. "Continuous" cross-firing obtained by relative rotation of phantom and beam. Other conditions as in Figure 7.

vorable to recommend this well established technique for most cases. In general, continuous cross-firing yields more striking results the smaller the tumor volume and the deeper its site.

TOTAL ABSORBED ENERGY

For the same deep tumor dose the total energy in gram-roentgens[9] absorbed by the patient is considerably greater with 200 kilovolt radiation than with supervoltage radiation. The absorption of the lower energy rays is accompanied by much side-scattering which diminishes the energy available for the tumor without reducing proportionately the total amount absorbed by the patient. As a result, the desired dose at the site of a deep tumor is attained at the expense of a relatively higher dosage in the intervening region between tumor and skin. This ratio of body dose to tumor dose is often further aggravated at the lower voltages by using large fields to increase the percentage depth dose. Nor is there at the lower voltages any significant "subcutaneous effect" to reduce the energy absorbed in the radiosensitive skin. It is probable that the relatively high skin and body dose account to a large extent for the frequent incidence of roentgen sickness observed with 200 kilovolt treatments as compared with supervoltage therapy. These considerations permit greater latitude with supervoltages in the choice of fractionation technique in that a higher daily tumor dose may be tolerably delivered.

CONCLUSIONS

(1) Roentgen rays produced by several million volts are capable of increasing the effectiveness with which deep tumors may be irradiated even without cross-firing.

(2) For 2 million volt radiation, the distribution of ionization in tissue is such as to avoid skin damage, deliver a more adequate dose at the typical 10 cm. depth, yet with a quite tolerable exit dose. The radiation beam is uniform across a large field area and has low back-scattering and side-scattering.

(3) Cross-firing becomes more effective with penetrating, low scattering skin favoring roentgen rays of several million volts' energy. With this technique, uniform deep tumor doses may be administered which are several times higher than the dose sustained by the skin and even tumor adjacent regions.

(4) For a given deep tumor dose, a smaller total dose is absorbed by the patient when treated with supervoltage radiation than when 200 kilovolt roentgen rays are used.

(5) As the roentgen-ray voltage is increased substantially beyond the several million volt range, some of the physical characteristics of resultant radiation beam become disadvantageous for therapy primarily because of non-uniformity of intensity across the beam and high exit dose.

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A RADIUM DOSAGE CALCULATOR

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THE Editor of the section on Radiotherapeutics in the 1945 Year Book of Radiology quotes a leader of the British group of radiologists, as follows:

"In general, statements of radium dosage are even more meaningless, authors being content to express dosage in terms of milligram hours without mentioning the screenage used, the area measurements, the thickness of the applicators, nor the physical arrangements of source, etc. For this there is only one answer: the adoption of the 'r' unit system in radium therapy." The Editor states that he is not ready to concede to all of these claims of fault, but there is no doubt that there is a kernel of truth in the statement and this constitutes a challenge to American radiology.

The International Committee for Radiological Units in 1937 established the present definition of the roentgen as the unit of dose of roentgen or gamma rays. The data for expressing radium dosage in roentgens have been carefully estimated and are available (Laurence,[2,3] Mayneord,[4] Quimby,[11,12,13] Roberts and Honeyburne,[14] van Roojen,[16] Sievert,[18,19] Wolfe[20]).

Dosage systems have been evolved (Jones,[1] Meredith and Stephenson,[5] Oddie,[6] Paterson and Parker,[8,10] Paterson, Parker and Spiers[9]). It is possible that these dosage systems have not been more widely accepted due to lengthy tables, multiple graphs, etc. which one must use with them. This feeling is evidenced by the recent publication of nomograms for linear sources by Wolfe,[21] of a multiple slide rule calculator for linear sources by Rudinger,[17] and a complete set of nomograms by Osborn.[7]

We therefore present a single slide rule calculator, so designed that the milligram-hours required to deliver 1,000 gamma roentgens, employing a filtration of 0.5 mm. platinum, can be simply and rapidly calculated for linear sources, volume implants, plane surface applicators, single and two plane interstitial implants and cylindrical surface applicators, in the hope that it may contribute to the further acceptance of the roentgen as a basis of radium dosage.

In addition to the above, the calculator will estimate radon decay and convert initial millicuries to millicurie-hours, and vice versa, for varying periods of time.

PART I

DESCRIPTION AND CLINICAL APPLICATION OF THE RADIUM DOSAGE CALCULATOR

By E. W. Spencer

The calculator front and reverse side is shown in Figure 1, *A* and *B*. Its brief description will be accompanied by illustrated calculations of type problems. It should be clearly understood that the ruler is a dosage calculator, and its use presupposes such an arrangement of radium sources as to give homogeneity over the part treated. Such arrangements are fully discussed in the dosage systems referred to above.

Linear Source Dosage. In Figure 1*A*, the top rule and upper scale of the sliding rule are for the calculation of dosage about linear sources. The upper scale of the rule marked "F_L for three linear sources" is a factor scale. Immediately below it is a scale marked "% Ra. in central source" for use with the above scale. The third scale reads r units opposite the end of the linear source, and below this, the scale marked "F_L (uniform density)" is a factor scale for linear sources of uniform density. The fifth and bottom scale of the upper rule "Linear source (*L*)" reads the

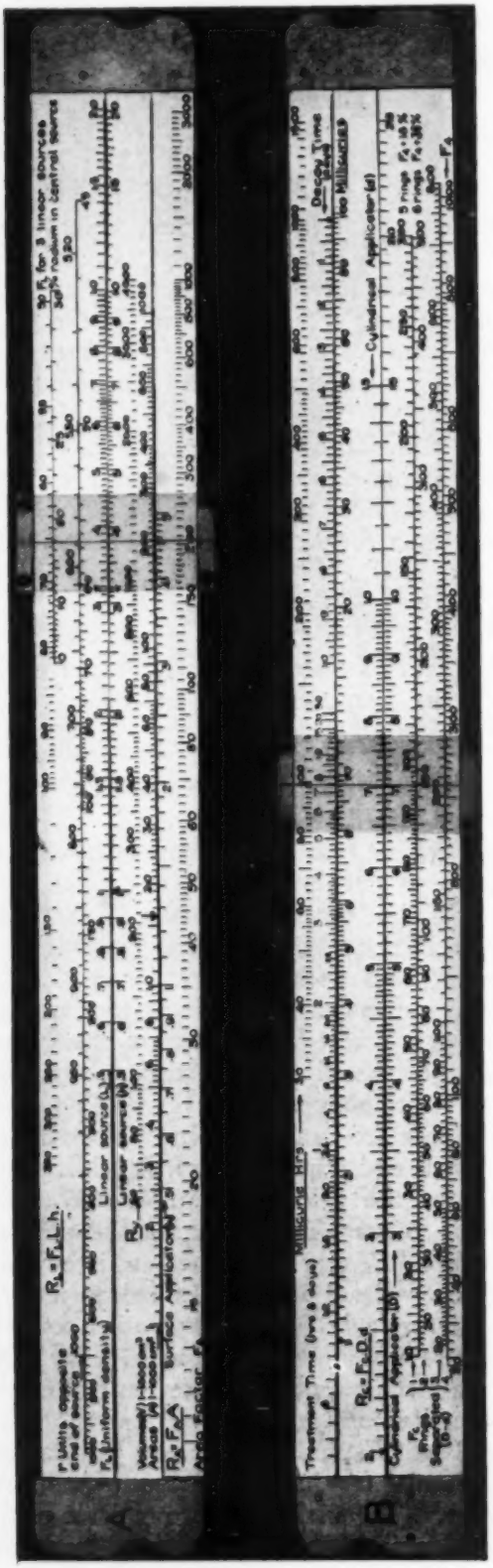

FIG. 1

active length of the linear source in centimeters from 0.5 to 20.

The upper scale of the slide "Linear source (h)" reads the perpendicular distance in centimeters from 0.5 to 10 from the center of the linear source, to a point at which the dose in milligram-hours to deliver 1,000 r is estimated.

Problem No. 1. It is required to find the milligram-hours to deliver 1,000 gamma roentgens (r_γ) at a point 2 centimeters perpendicular to the center of a linear source of uniform density, 10 cm. in length (filtration 0.5 mm. Pt). It is also required to find the dosage in gamma roentgens opposite the end of such a source.

Solution (see Fig. 2).

1. Set the hair line of the cursor opposite 10

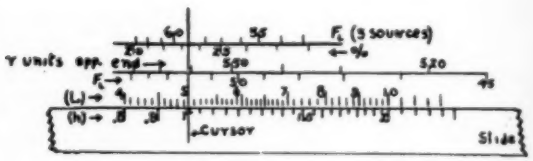

FIG. 2

on the "Linear source (L)" scale (lower scale of upper rule).

2. Adjust the slide so that 2 on the "Linear source (h)" scale (upper scale of slide) is also under the cursor hair line.

3. Adjust the cursor opposite the up pointing arrow (at 1 on the "Linear source (L)" scale).

4. Read the factor 52 on the "F_L uniform density" scale.

5. As indicated on the upper left portion of the ruler, R_L (milligram-hours to give 1,000 r equals $F_L \times L \times h = 52 \times 10 \times 2 = 1{,}040$ milligram-hours to give 1,000 r opposite the center of the source. Paterson and Parker's[8] graphs and tables read 1,042 mg-hr., and Wolfe[21] shows 1,063 mg-hr. as a solution to the above problem.

6. The figure 560 on the "r units opposite end of linear source" scale immediately above the factor 52, is the r units opposite the end of the source. Wolfe[21] shows 563 r for this problem.

Problem No. 2. It is required to arrange the above 10 cm. linear source as three sources in tandem, and to find the milligram content of each source, and the milligram-hours necessary

to deliver 1,000 r homogeneously along the full length of the source at a 2 cm. distance.

Solution (see Fig. 2).

Follow steps 1, 2, and 3 as above.

4. Read the factor 59 on the top (F_L for 3 linear sources) scale.

5. $R_L = 59 \times 10 \times 2 = 1{,}180$ mg-hr. to deliver 1,000 r.

6. Immediately below the factor 59, read the "% content of the central source" = 23.5 per cent. The end sources will then contain 38.25 per cent of the total radium. Jones'[1] graphs give 1,200 mg-hr. required with 23.2 per cent radium in central source as a solution to this problem.

If filtrations other than 0.5 mm. Pt are employed, the calculator may still be used with the correction that the milligram-hours calculated will deliver other than 1,000 r as shown in Table 1. This table is adapted from Wolfe.[20] It should also be noted that if three linear sources in tandem are used, and the factor F_L is greater than 82, the central source contains no radium.

TABLE I

1 mm. Pt	1.5 mm. Pt	2 mm. Pt
Ratio $\frac{L}{h} < 4$	Ratio $\frac{L}{h} < 2$	Ratio $\frac{L}{h} < 2$
900 r	800 r	700 r
Ratio $\frac{L}{h} > 4$	Ratio $\frac{L}{h} > 2$	Ratio $\frac{L}{h} > 2$
850 r	750 r	650 r

Volume Dosage. Again in Figure 1*A*, the middle scale "R_v" and the bottom scale "volumes (V) 1 to 1,000 cm.^{3}" on the slide, are for interstitial volume calculations. These are limited to such geometric volumes as cylinders, spheres and cubes. This scale was extended to 1,000 cm.^{3} for convenience in its preparation. As will be pointed out later, the same scale serves for areas from 1 to 1,000 cm.^{2}. Areas beyond 100 cm.^{2} and volumes beyond 400 cm.^{3} will very rarely, if ever, be treated.

Problem No. 3. To find the milligram-hours required to deliver 1,000 r interstitially to a cylindrical volume of 30 cc. (0.5 mm. Pt filtration).

Solution (see Fig. 3).

1. Find figure 30 on the bottom (volume V–1–1,000 cm.^{3}) slide scale.

2. Immediately above it on the R_v scale,

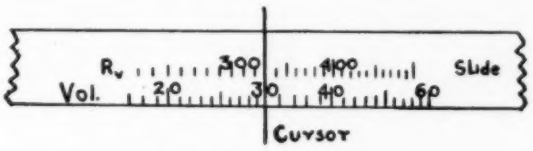

FIG. 3. Volume dosage.

read 330 mg-hr. to deliver 1,000 r. This corresponds with Paterson and Parker's[10] volume dosage graph.

Plane Superficial Applicator Dosage. Again in Figure 1*A*, the lower scale of the slide "Area –*A*–1–1,000 cm.^{2}" as well as volumes, reads plane superficial applicator areas. The top scale of the bottom rule "surface applicators (h)" reads the treatment distance from 0.5 to 5 cm. for superficial plane applicators. Immediately below this, the lower scale of the bottom rule "area factor (F_A)" is a factor scale.

Problem 4. It is required to find the milligram-hours to deliver 1,000 r to an area of 13 sq. cm. with a superficial plane applicator at a treatment distance of 1 cm. (0.5 mm. Pt filtration).

Solution (see Fig. 4).

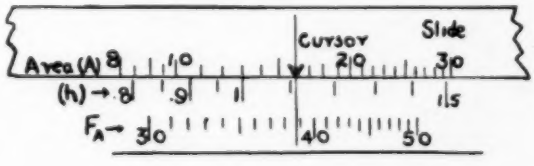

FIG. 4

1. Set the cursor opposite the distance "1" on the "surface applicator (h)" scale (upper scale of the bottom rule).

2. Adjust the slide rule so that the area 13 on the "Area *A*–1–1,000 cm.^{2}" (lower scale of slide) also reads under the cursor.

3. Adjust the cursor over the down pointing

arrow (at "16" on the area scale) and read the factor 38.7 on the lower area factor (F_A) scale.

4. As indicated in the lower left portion of the ruler, "R_A" (milligram-hours to deliver 1,000 r) $= F_A \times A = 38.7 \times 13 = 503$. Paterson and Parker's[8] graphs read 502 mg-hr. as a solution to this problem.

In the preparation and use of surface applicators, one frequently finds that the

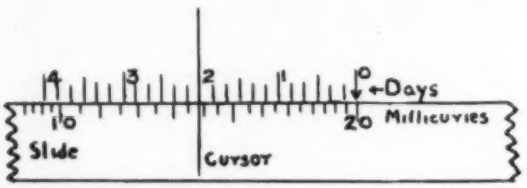

FIG. 5. Radon decay.

applicator, when completed, is not exactly the thickness on which calculation was based. Roberts[15] has pointed out the extreme importance of accuracy in this estimation, particularly for small areas. If the treatment distance is other than that originally presumed, the new dosage can be very readily found with the calculator.

Dosage for two plane interstitial implants is calculated as above, using a treatment distance of 0.5 cm. For two plane interstitial implants, correction must be made for the separation of the planes as shown by Paterson and Parker.[10]

For the calculation of plane surface ap-

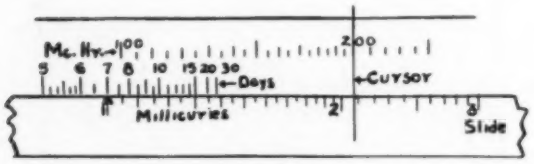

FIG. 6

plicators, single and two plane interstitial implants, volume dosage and cylindrical surface applicators, using filtrations other than 0.5 mm. Pt the milligram-hours calculated will deliver roentgens as shown in Table II. These corrections have been adapted from Paterson and Parker.[10]

Radon Decay and Millicurie-Millicurie-Hour Conversions. Figure 1*B* illustrates the opposite side of the calculator. The top portion of the rule and upper scale of the slide are used for radon calculations and conversions. The upper scale of the rule is a millicurie-hour scale. The left portion of the scale immediately below this represents treatment time, hours and days, from six hours to thirty days.

The right portion of this same scale represents radon decay time in days from 0 to 10. The upper scale of the slide is a millicurie scale.

TABLE II

0.3 mm. Pt	0.8 mm. Pt	1 mm. Pt	1.5 mm. Pt	2 mm. Pt
1050 r	940 r	900 r	850 r	750 r

Problem 5. Given an initial 20 millicuries of radon, find the millicuries alive and millicuries-destroyed in two days' time.

Solution (see Fig. 5).

1. Adjust the slide so that 20 on the millicurie scale (upper scale of the slide) reads opposite the down pointing arrow at 0 on the decay time (days) scale (lower scale of rule).

2. Adjust cursor opposite two days on the "decay time (days)" scale and read 13.9 mc. alive on the millicurie scale. Millicuries-destroyed will then be 6.1. Standard tables show 13.98 mc. alive.

Problem 6. It is required to find the initial millicuries to deliver 200 mc-hr. over seven days' time.

Solution (see Fig. 6).

1. Adjust the cursor opposite 200 on the millicurie-hour scale (upper scale of rule).

2. Adjust the slide so that the up pointing arrow (at 1 on the millicurie scale) is opposite 7 days on the left "treatment time (hours and days)" scale.

3. On the millicurie scale, upper slide scale, under the cursor, read 2.1 initial millicuries required.

Cylindrical Surface Applicator Dosage. Again in Figure 1*B*, the lower scale of the slide and the lower rule are for the calculation of cylindrical surface applicators. The

lower scale of the slide "cylindrical applicator (d)" reads the diameter of the part to be treated in centimeters from 2 to 15.

The upper scale of the lower rule "cylindrical applicator (*D*)" reads the diameter of the applicator with centimeters from 3 to 20.

The lower four scales of the lower rule "F_C, rings separated (D–d) 1, 2, 3, 4" are factor scales. Note that there is no statement of the length of the part to be treated nor of the cylindrical applicator. The selection of the appropriate factor scale is a function of the length, as will be shown in the following problem.

Problem 7 (see Fig. 8). It is required to determine the milligram-hours to deliver 1,000 r to the surface of a cylindrical anatomic region, using a cylindrical applicator (0.5 mm. Pt filtration). The diameter of the part to be treated is 4 cm. The treatment distance is to be 1 cm. and the length of the area to be treated is 4 cm.

Solution (see Fig. 7).

1. The treatment distance is 1 cm. and the diameter of the treated part is 4 cm. Therefore the diameter "D" of the cylindrical applicator

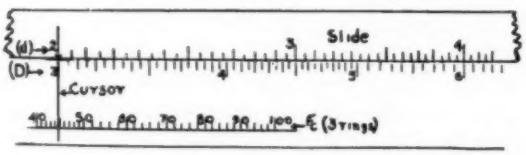

Fig. 7

must be 6 cm. Adjust the cursor over 6 on the "cylindrical applicator (*D*)" scale.

2. Adjust the slide so that the diameter of the treated part, 4 cm. "cylindrical applicator (*d*)" scale also reads under the cursor.

3. Adjust the cursor over the down pointing arrow at 2 on the same scale.

4. For proper distribution, the ring sources of radium must be separated a distance of D–d, which in this case is 2 cm. The length of the applicator is 4 cm., and therefore three ring sources must be used. The factor F_C now under the cursor is therefore read on the three ring scale and is 44.8.

5. R_C (milligram-hours to deliver 1,000 r) $= F_C \times D \times d = 44.8 \times 6 \times 4 = 1{,}075$. Paterson, Parker and Spiers[9] give 1,080 mg-hr. as a solution to this problem.

If only two rings are used, the radium would be distributed evenly between them. When three or more rings are employed, the radium is

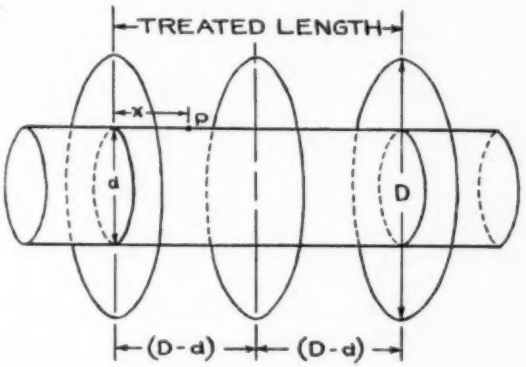

Fig. 8

distributed 1:2/3 etc.:1. At the right hand of the lower rule are correction percentages for five and six ring distributions.

Finally the ruler may be used as an ordinary slide rule calculator. The "linear source (*L*)" and "linear source (*h*)" scales, the first on the rule and the second on the slide are 1–10 log. scales, and may be used for ordinary calculations. For convenience in calculating circular areas the constant π is shown on these scales.

If 1 on the area scale is set opposite 1 on the "surface applicator (*h*)" scale, squares and square roots can be read directly.

Part II

The Mathematical Basis and Construction of the Calculator

By H. E. Johns

The clinical uses of this calculator have been described in Part I of this paper. In this section the mathematical background will be discussed and tables of values will be given so that a slide rule can be constructed. This particular slide rule has been designed throughout for 0.5 mm. of platinum filtration. Rulers for other filtrations could be made in a similar way. The intensity 1 cm. from a 1 mg. source of radium

filtered by 0.5 mm. Pt has been taken as 8.4 r per hour. The paper will deal in turn with (1) plane surface applicators; (2) volume dosage; (3) linear sources; (4) cylindrical surface applicators, and (5) decay of radon.

(1) *Plane Surface Applicators.* Surface applicators have been discussed by Paterson and Parker,[8] Quimby[11] and subsequently by Oddie.[6] The calculations are based on Sievert's[18,19] ring formula

$$I_b=\frac{(8.4)m}{\sqrt{(a^2+b^2+h^2)^2-4a^2b^2}}$$

in which I_b gives the intensity of radiation in r per hour at a point on a plane at a distance h from the plane of the applicator. The applicator contains m mg. of radium uniformly distributed on a circle of radius a. The intensity is given for a point distance b from the center of the circular area treated. The average intensity over the treated area A (a circle of radius a) will be given by

$$I_{av}=\frac{1}{A}\int_{b=0}^{b=a} I_b 2\pi b\cdot db.$$

This integral can be evaluated to give

$$I_{av}=\frac{8.4m\ (2.303)\pi}{A}\log_{10}(0.5+\sqrt{0.25+y}).$$

where $y=A/\pi h^2$. Consequently R_A (the number of milligram-hours to give an average dose of 1,000 r over the treated area) is given by

$$R_A=\frac{1{,}000\ m}{I_{av}}=F_A\cdot A$$

where

$$F_A=\frac{16.47}{\log_{10}(0.5+\sqrt{0.25+y})}.$$

Paterson and Parker[8] have shown that for $a/h<1.5$ the variation of intensity over the treated surface is within the limits ± 10 per cent. For $1.5<a/h<3.0$ they suggest an added central source of radium containing 5 per cent of the radium, and for larger values of a/h two rings with a central source. For example for $a/h=3$ the outer ring should contain 80 per cent of the radium, the inner ring of half the radius 17 per cent, and the central source 3 per cent. When these more complicated arrangements suggested by Paterson and Parker[8] are used it is found that R_A can still be expressed by $F_A\cdot A$ where F_A now takes the forms indicated below. It will be seen that in all cases F_A is a function of the one variable y.

$$a/h<1.5 \qquad F_A=16.47\frac{1}{B}$$

$$1.5<a/h<3.0 \qquad F_A=\frac{16.47}{0.95B+0.05D}$$

$$a/h=3 \qquad F_A=\frac{16.47}{0.80B+0.17C+0.03D}$$

$$a/h=3.75 \qquad F_A=\frac{16.47}{0.75B+0.22C+0.03D}$$

$$a/h=5.0 \qquad F_A=\frac{16.47}{0.70B+0.27C+0.03D}.$$

Where

$$B=\log_{10}(0.5+\sqrt{0.25+y})$$

$$C=\log_{10}(0.5+0.375y+0.125\sqrt{16+40y+9y^2})$$

$$D=\log_{10}(1+y).$$

B, C and D are the factors arising from the integration of the intensities produced respectively by the outer and inner circles and the central source.

Since F_A is a function of y, or of $h/\sqrt{A}$ the results can conveniently be put on a slide rule thus.

On the slider areas A from 1 to 1,000 cm.^{2} are given (see Fig. 1*A*, Part I), and on the fixed scale adjacent to it distances h from 0.5 to 5.0 cm. are recorded using a log scale in each case such that the distance from 0.5 to 5.0 cm. is equal to the distance from 5 to 500 on the slider, the length being unimportant. When distance h and area A are set opposite one another the ratio $h/\sqrt{A}$ is automatically obtained on the h scale opposite the 1 on the area scale and an arrow on the slider points to a value of F_A on the F_A scale. To bring the area factor scale near the center of the ruler the index mark was arbitrarily placed at 16 on the area scale. The area factor scale must now be placed in a very definite position with respect to the h scale. The F_A scale is not a log scale however. It is sufficiently accurate to locate certain F_A values and divide the intervals by logarithmic interpolation. The values of F_A have been calculated for different values of

$h/\sqrt{A}$ using the above relations and are tabulated in Table III. For example, Table III shows that $F_A=20$ should be opposite 0.512 on the h scale when the index mark is set at $A=16$. For large values of F_A the F_A scale is very nearly logarithmic so that logarithmic interpolation is accurate even for large intervals. If the values given in Table III are used no calculations need be made to make the F_A scale.

The results of Table III agree to within 1 per cent with those of Paterson and Parker[8] and to within 2 or 3 per cent with those of Oddie[6] when due allowance in the latter case is made for the fact that 8.0 r/hr. was used instead of the 8.4 mentioned above.

The area factor scale refers to squares or circles. If other shapes such as rectangles are used certain elongation correction factors must be introduced.[8]

(2) *Volume Dosage.* Paterson and Parker[10] have shown that for volume dosage R_V (the number of milligram-hours to give 1,000 r) is given by $R_V=34.1\ V^{2/3}$ where V is the volume to be implanted.

The area scale from 1 to 1,000 cm.^{2} can be used also to represent volumes from 1 to 1,000 cm.^{3} (see Fig. 1*A*, Part I). For each value of V there is a definite value for R_V which appears on the sliding scale directly above the V scale. This R_V scale is logarithmic going through two complete cycles while the V scale goes through three complete cycles. The R_V scale can most conveniently be placed on the rule by locating the point $R_V=100$ which corresponds to $V=5.01$ cm.^{3} and $R_V=1{,}000$ which corresponds to $V=158.5$ cm.^{3} If a sheet of triple cycle log paper is rotated until the middle section of the paper exactly matches these two points all the other points on the R_V scale will be located automatically.

For shapes other than the sphere, cube and regular cylinder certain corrections must be added to R_V. These have been discussed by Oddie.[6]

(3) *Linear Sources.* The intensity of radiation opposite the mid-point of a linear source of active length L at a distance h is given by Sievert's formula:[18]

$$I=\frac{2Bm}{hL}\cdot I_1$$

where

$$I_1=\int_0^{\phi_1} e^{-\mu d/\cos\theta}\ d\theta \quad \text{and} \quad \tan\phi_1=L/2h.$$

B is the radiation intensity in r per hour 1 cm. from a 1 mg. source of radium unfiltered by any platinum, m is the number of milligrams of radium in the source, d the wall thickness of the cylindrical container and μ the linear absorption coefficient of the absorbing wall. B has been taken equal to 9.28 r/hr. as this leads to the value 8.4 r/hr. when the filtration is 0.5 mm. Pt. μd takes the value 0.10 for this filtration. Using this relation it is seen that R (the number of milligram-hours to deliver 1,000 r opposite the center of the source) is given by R_L $1{,}000m/I=F_L\cdot L\cdot h$ where $F_L=53.8/I_1$. Similarly it can be shown that when the dose is 1,000 r opposite the middle of the source the dose opposite the end is $1{,}000\ I_2/2I_1$ where

$$I_2=\int_0^{\phi_2} e^{-\mu d/\cos\theta}\ d\theta \quad \text{and} \quad \tan\phi_2=L/h.$$

Since F_L and I_2/I_1 are both functions of L/h a certain ratio for L/h will uniquely determine both F_L and the relative dose opposite the end of the source. The results can therefore be placed on the slide rule, thus:

On the top part of the slider just above the R_V scale an h scale from 0.5 to 20 cm. was constructed and opposite it on the fixed scale an active length scale identical with it was produced, both being true log scales (see Fig. 1*A*, Part I). When L and h are set opposite one another on these scales the ratio L/h is obtained above $h=1$ and an arrow at $h=1$ points to a value on the F_L scale which corresponds to this value of L/h. The F_L scale can be placed on the ruler using the information given in the first section of Table IV. When the points given

TABLE III

PLANE SURFACE APPLICATORS

F_A	$h/\sqrt{A}$	h for $A=16$	F_A	$h/\sqrt{A}$	h for $A=16$
12	0.056	0.224	150	0.924	3.70
15	0.084	0.336	200	1.12	4.48
20	0.128	0.512	300	1.44	5.76
25	0.167	0.668	400	1.70	6.80
30	0.207	0.828	600	2.14	8.56
40	0.288	1.15	800	2.49	9.96
50	0.367	1.47	1000	2.80	11.2
60	0.437	1.75	2000	4.03	16.1
80	0.571	2.29	3000	4.98	19.9
100	0.680	2.72			

in Table IV are located the intervals can be divided by logarithmic interpolation. Similarly the information needed for the construction of the scale giving the dose opposite the end of the source is recorded in the second section of Table IV. The data in Table IV were obtained directly from Sievert's integrals[19] and agree with the results of Quimby[12] and Wolfe[21] when due account is taken of the assumed intensity 1 cm. from a 1 mg. source.

Recently Jones[1] has shown that homogeneity over the active length of the source can be achieved if three sources of the same active length are used with the central source containing a certain fraction, f, of the total amount of radium. He showed that to achieve this end the following condition must be satisfied:

$$(3a-1)\tan^{-1}(L/2h)-(4a-3)\tan^{-1}(L/6h)-a\tan^{-1}(5L/6h)=0$$

where $a=(1-f)/2f$. It will be seen that the percentage content of the central source is a function of the ratio L/h. The values for f are tabulated in the last section of Table IV and appear on the slide rule above the last two scales described. Table IV shows that for $L/h=2.4$ the fraction in the central source is zero. For L/h less than 2.4 the percentage in the central source should be negative, as Jones[1] has pointed out. If L/h is less than 2.4 the best that can be done is to leave an inactive gap in the central third.

R_L is still given by $F_L \cdot L \cdot h$ but the factor F_L now takes the form

$$\frac{35.95}{I_2-I_1}$$

for $L/h<2.4$ and

$$\frac{35.95}{I_2(1-f)-I_1(1-3f)}$$

for $L/h>2.4$ where $I_1 I_2$ and f have the meanings given above. The values for F_L corresponding to different values of L/h are given in the third section of Table IV. The F_L scale for this case is not extended beyond 350 since for small values of L/h the scale for three linear sources becomes identical with the scale for 1 linear source.

(4) *Cylindrical Applicators.* The problem of

TABLE IV

LINEAR SOURCES

Single Source of Uniform Density				Three Colinear Sources			
F_L	(L/h)	Dose Opp. End (r)	(L/h)	F_L	(L/h)	Per Cent in Central Source	(L/h)
1000	0.119	1000	0.17	350	0.349	0	2.40
800	0.149	990	0.26	300	0.410	10	2.94
600	0.200	970	0.40	250	0.492	15	3.42
500	0.240	950	0.49	200	0.628	20	4.16
400	0.301	900	0.70	150	0.860	25	5.60
300	0.403	850	0.94	120	1.16	28	7.60
250	0.486	800	1.22	100	1.50	30	10.05
200	0.611	750	1.53	90	1.86		
150	0.835	700	1.91	83	2.27		
120	1.10	650	2.50	82	2.45		
100	1.37	600	3.45	70	3.28		
90	1.57	570	4.55	65	3.87		
80	1.87	550	5.80	60	4.78		
70	2.35	530	8.40	55	6.38		
60	3.22	520	11.50	50	9.60		
55	4.10						
50	5.92						
47	8.60						
45	14.1						

placing the data for cylindrical applicators on a slide rule provides some difficulty because the value R_C (the number of milligram-hours to give an average dose of 1,000 r over the surface of the cylinder) will involve three variables—the length of cylinder L, the diameter of treated cylinder d, and the diameter of the cylindrical applicator D.

Paterson, Parker and Spiers[9] have shown that to obtain uniform intensity (±10 per cent) over the treated cylinder the rings of radium should be spaced distance $(D-d)$ apart. For two rings the strength of both rings should be the same but for three rings in the ratio 1:1/2:1, for more than three rings in the ratio $1:2/3:2/3 \cdots :1$. I have found that even for three rings the distribution 1:2/3:1 is slightly better, although the difference is small, and in the calculations which follow the distribution $1:2/3 \cdots 1$ has been used for three or more rings.

In Figure 8, Part I, three rings of radium of diameter D and the cylinder to be treated of diameter d are illustrated. The rings are $D-d$ apart. The intensity at P due to the left hand ring is given by Sievert's formula,

$$I_p=\frac{8.4\ m/2}{\sqrt{\left(\frac{d^2}{4}+\frac{D^2}{4}+x^2\right)^2-\frac{d^2D^2}{4}}}$$

where $m/2$ is the amount of radium in one ring. The average intensity over the treated cylinder is given by

$$I_{av}=\frac{1}{L}\int_{x=0}^{x=L} I_p dx.$$

If the substitutions

$$x=\frac{D-d}{2}\cdot\tan\theta,\quad f=\frac{d}{D}\quad\text{and}\quad k^2=\frac{4dD}{(D+d)^2}$$

are made, and if the intensity is doubled due to the second ring, it can be shown that for two rings spaced $D-d$,

$$I_{av}=\frac{16.8\ m\cdot f}{d\cdot D\cdot(1-f^2)}\ I_1$$

where

$$I_1=\int_0^{\tan^{-1}2}\frac{d\theta}{\sqrt{1-k^2\sin^2\theta}}.$$

Therefore

$$R_C=\frac{1{,}000\ m}{I_{av}}=F_C\cdot D\cdot d$$

where

$$F_C=59.5\ \frac{1-f^2}{f}\cdot\frac{1}{I_1}.$$

If n rings with a distribution $1:2/3:2/3 \cdots 1$ are used it can be shown that R_C is still given by $F_C\cdot D\cdot d$ where

$$F_C=59.5\ \frac{(1-f^2)}{f}\ \frac{(n^2-1)}{\{3I_{n-1}+2(I_1+I_2\cdots I_{n-2})\}}$$

and

$$I_2=\int_0^{\tan^{-1}4}\frac{d\theta}{\sqrt{1-k^2\sin^2\theta}}$$

$$I_3=\int_0^{\tan^{-1}6}\frac{d\theta}{\sqrt{1-k^2\sin^2\theta}}\ \text{etc.}$$

The integrals I_1, I_2 and I_3 are well known elliptic integrals whose values may be found in tables.

If one ring is used and if for this case R_C is interpreted as giving the number of milligram-hours to deliver a dose of 1,000 r to a point on the cylinder directly under the ring, then $R_C=F_C\cdot D\cdot d$ where

$$F_C=\frac{59.5}{2}\ \frac{(1-f^2)}{f}.$$

At a point half the treatment distance $((D-d)/4)$ from the plane of the ring the dose falls to 900 r for $f=0.25$ and 860 r for $f=0.75$. One ring can therefore be considered as adequately irradiating a length approximately equal to the treatment distance $(D-d)/2$.

It will be seen that in all cases R_C is given by

$$R_C=F_C\cdot D\cdot d$$

where F_C is a function of d/D and also the number of rings. A different scale F_C is therefore needed for each different number of rings. However, to within an accuracy of 2 per cent the factor for five rings can be obtained from that for four rings (F_4) by increasing F_4 by 18 per cent. F_6 can be obtained from F_4 by increasing F_4 by 36 per cent the error now being for extreme values of d/D about 4 per cent.

The results for cylindrical applicators can be put on the slide rule since for a definite number of rings, F_C is a function of d/D. The values for the diameter d of the treated cylinder were laid out from 2 to 15 cm. on the lower part of the movable scale (see Fig. 1*B*, Part I) and the diameter D of the cylindrical applicator from 3 to 25 on the fixed scale just opposite it. Both

TABLE V

CYLINDRICAL SURFACE APPLICATORS

F_C	1 Ring D/d	2 Rings D/d	3 Rings D/d	4 Rings D/d
10	1.18	—	—	—
20	1.39	1.26	1.21	1.16
30	1.62	1.42	1.32	1.26
40	1.88	1.59	1.44	1.36
50	2.14	1.74	1.56	1.45
60	2.43	1.91	1.68	1.55
70	2.72	2.08	1.80	1.65
80	3.01	2.26	1.92	1.74
90	3.31	2.45	2.05	1.84
100	3.65	2.62	2.17	1.94
120	4.27	2.99	2.42	2.13
150	5.24	3.52	2.78	2.43
170	5.86	3.89	3.05	2.62
200	7.85	4.45	3.43	2.92
250	8.40	5.39	4.07	3.42
300	10.0	6.25	4.74	3.94
350	—	7.20	5.40	4.43
400	—	8.15	6.02	4.93
450	—	9.08	6.67	5.45
500	—	10.0	7.30	5.98
600	—	—	8.58	7.03
700	—	—	9.85	8.02
800	—	—	11.1	9.00
900	—	—	—	9.95
1000	—	—	—	10.7

scales are true log scales. The index arrow was placed at 2.0 on the "d" scale as this brought the factors F_C to the central portion of the ruler. The F_C scales can be located by using the results of Table v which were obtained using the relations above. For example $F_C = 10$ occurs for one ring at $D/d = 1.18$ so D must be 2.36 when $d = 2.0$. Therefore, $F_C = 10$ should be opposite 2.36 on the D scale. When the values of F_C given in Table v are located in this way the intervals may be divided by interpolation. The F_C scales are nearly logarithmic for large values of F_C and nearly linear for small values.

It should be pointed out that the treated length, except for one ring, is the distance between the extreme rings. Essentially the same results will be obtained if the radium is placed as a series of linear sources parallel to the axis of the cylinder with a ring at each end as Paterson, Parker and Spiers[9] have indicated.

(5) *Decay of Radon.* The scales dealing with the decay of radon are designed to solve two problems.

(a) To give the strength of any radon source after a given decay time.

(b) To give the number of millicurie-hours delivered by any initial strength source in any treatment time.

(a) A source of initial strength I_0 will have after time t a strength I given by $\log_e(I/I_0) = -\lambda t$. This result can conveniently be placed on the slide rule by using a log millicurie scale from 1 to 100 adjacent to an inverse linear time scale from 1 to 10 days (see Fig. 1*B*, Part I). When the initial strength is placed opposite time 0 the strength at any subsequent time can be read off directly. The linear time scale can be fixed by making the distance from 0 to 3.85 days equal to the length of the millicurie scale between 100 and 50.

(b) A radon seed of initial strength I_0 will in time t deliver R millicurie-hours where

$$R = I_0 \cdot F(t) \text{ and where } F(t) = (1 - e^{-\lambda t})/\lambda.$$

$F(t)$ is actually the number of millicurie-hours delivered by a source having an initial strength of 1 mc. in a time t.

The values of $F(t)$ for give values of t have been recorded by many workers. R is seen to be the product of two factors. The millicurie scale used for problem (a) can be used here, but there are needed also a millicurie-hour scale from 30 to 1,500 and a treatment-time scale from 8 hours to 30 days. The millicurie-hour scale is a log scale such that the distance from 100 to 1,000 corresponds to one cycle on the millicurie scale. It can be placed anywhere on the fixed scale. The treatment-time scale must be placed in a very definite position with respect to it. For example 2 days must be opposite 40.5 mc-hr. since in 2 days 1 mc. (initially) will deliver 40.5 mc-hr. The other points on this time scale can be placed by calculations of $F(t)$ or by reference to tables giving values of $F(t)$. When the value 1 mc. is placed opposite the treatment time chosen the number of millicurie-hours delivered by any given value of the initial strength can be read off the millicurie-hour scale directly opposite the point corresponding to the initial strength.

In partial summary it has been shown that:

(1) For plane surface applicators R_A (the number of milligram-hours to deliver an average dose of 1,000 r over the treated area) is given by $F_A \cdot A$ where F_A is a function of $h/\sqrt{A}$. Consequently for given values of A and h one setting on the slide rule determines the factor F_A and hence R_A may be calculated.

(2) For volume implants R_A (the number of milligram-hours to deliver 1,000 r to the treated volume) may be read directly from the ruler.

(3) For linear sources R_L (the number of milligram-hours to deliver 1,000 r to a point opposite the center of the source) equals $F_L \cdot L \cdot h$ where F_L is a function of L/h. Hence for given values of L and h one setting of the slide rule determines a factor F_L from which R_L may be calculated. This setting also serves to determine the dose opposite the end of the needle. In case homogeneity is required over the length of the source the same setting determines the per cent of the radium required in the central source and a new F_L factor.

(4) For cylindrical surface applicators R_C (the number of milligram-hours to deliver an average dose of 1,000 r over the surface of the treated cylinder) equals $F_C \cdot D \cdot d$ where F_C is a function of the number of rings and the ratio D/d. After the number of rings required is determined from the length to be irradiated, the factor F_L may be obtained from one setting of the ruler and R_C calculated.

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ADDITIONAL NOTE

Since the manuscript was sent to the publishers several slight changes have been made in the slide rule.

Filtration. For linear sources the filtration correction is troublesome since it depends on L/h. When L and h are set opposite one another on the ruler the up pointing arrow determines F_L and also the filtration correction. Letters just below the F_L scale refer to a table of filtration corrections on the upper left hand corner of face A of the ruler. With this small addition Tables I and II of this paper need not be used.

Distribution Rules. For circular surface applicators the proper distribution of radium depends on a/h or $\sqrt{A}/h$ and is automatically determined when A and h are set opposite one another on the ruler. The percentage radium required in the central spot, inner ring and outer ring appear just above the F_A scale. The difficult distribution rules need not be remembered with this addition.

Intermittent Radon Treatment. The calculation of the dose delivered during an intermittent radon treatment can be simply done by the addition of one scale giving hours per day on the slider just below the millicurie scale face B.

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VARIATIONS IN INTERLOBAR FISSURES*

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VARIATIONS from an accepted norm usually receive scant attention and often are considered as infrequent anomalies. In medical diagnoses, the variations in structure of an organ, especially if of frequent occurrence and of major extent, need to be considered of importance equal to that of the accepted norm. In no organ is this truer than in the lung where localization of pathological processes and interpretations of abnormal shadows are so frequently made from roentgenograms of the chest. Textbooks of anatomy merely mention that variations in lung structure do occur and the medical literature dealing with pulmonary conditions record isolated observations of pulmonary anomalies. The only references to examination of considerable numbers of lungs for fissure variations known to me are two reports commented upon by d'Hour.[1] One of these was the report of Dévé who found the lesser fissure incomplete in 90 of 180 infant lungs with this fissure being wholly absent 4 times and a simple indenture 9 times. Brites' study of 570 cadavers was quoted as having found classical or complete fissures in only 35 per cent on the right and in 83 per cent on the left. To record the frequency and extent of variations in fissure formation, and hence of lobar divisions of the lung, I present my observations on 1,200 pairs of lungs in cases of sudden death from the Medical Examiner's Department of the Borough of Manhattan. Variations in the interlobar fissures are presented in Table 1.

The recording of any fissure as complete denotes that the lung parenchyma is separated down to the hilum of the lung. In a considerable number of the fissures so listed in Table 1, a band of connective tissue, often 2 centimeters in depth, was all that separated the lobes. This band of connective tissue could be severed by sharp dissection down to the large vessels and bronchi at the hilum without cutting lung parenchyma. The percentages of complete fissures in this table are very similar to those reported by Brites.

TABLE I

VARIATIONS OF INTERLOBAR FISSURES OF THE LUNGS IN 1,200 CONSECUTIVE NECROPSIES

Place of Fissure	Total	Condition of Fissure		
		Complete	Over half complete	Less than half complete to no fissure
Left lung	1,200	985 (82.1%)	127 (10.6%)	88 (7.3%)
Right lung Major fissure	1,200	835 (69.6%)	308 (25.6%)	57 (4.8%)
Right lung Middle lobe fissure	1,200	452 (37.7%)	205 (17.1%)	546 (45.2%)

The most frequently interpreted fissure in roentgenograms of the chest is that of the right middle lobe and the shadows seen

* The material for this study became available through the cooperation of the Medical Examiner's Department of the Borough of Manhattan.

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are very commonly interpreted as due to interlobar adhesions. If this interpretation is correct, then diagnosable adhesions would seem to occur most often where fissures are incomplete most frequently. It was a common occurrence to find an increased amount of connective tissue in the incomplete fissure line which often extended into the lung substance for a distance of 1 or 2 cm. By sharp dissection, the lobes could be separated as far as the connective tissue extended after which there was no separation of the lung parenchyma. This condition existed where there was no suggestion of pulmonary or pleural pathology and was seen in several instances in newborn babies. It is apparent that a considerable number, probably the majority, of the middle lobe fissures observed in roentgenograms are due to this increased connective tissue in incomplete fissures. Whether a shadow would be cast by this connective tissue would depend upon the density of the tissue, the depth of the tissue band and the angle at which the roentgenogram was taken. During the study, I had the opportunity to examine 2 cases at necropsy where the middle lobe fissure shadow was very prominent in antemortem roentgenograms of the chest. In both instances, the shadow was due to an increased amount of connective tissue in incomplete fissures, not to interlobar adhesions. In 200 pairs of lungs used in this study, pleural adhesions extended over fissure areas, often with complete obliterative pleuritis, and in all of these specimens, the extent of the fissure could be readily determined because the adhesions could easily be broken by blunt dissection. In a number of instances, there were no interlobar adhesions even when the whole general pleural space was obliterated.

In the area where there is a complete lack of a part of a fissure, the pulmonary lobules from the different lobes are inextricably enmeshed. I have observed 2 cases in which tuberculosis of the upper lobe had extended directly into the lower lobe because of lack of fissure but I have never seen an extension of tuberculosis through both pleural surfaces where a fissure was complete. This same condition has been observed in lung abscesses and in lobar pneumonia. Fissures, when present, are a very definite barrier to the spread of infection from one lobe to another. This situation deserves the careful consideration of those who interpret roentgenograms of the chest as well as of the surgeon when lobectomy or dissection of pulmonary lobules is contemplated.

Complete absence of the middle lobe fissure in the right lung was noted in 160 specimens. In every instance of this sort, the bronchus had its normal origin as a branch from the main bronchus of the lower lobe. In several specimens, there was an incomplete fissure between the middle and lower lobe. When this condition was accompanied by an incomplete fissure between the upper and middle lobe, the lung was essentially a single-lobed organ. In all the specimens where the main fissures were less than half-formed, 145 in all, the lung could be considered as a single-lobed organ. It was rare to have a complete absence of the main fissure.

In the left lung, there were 2 instances where a complete extra fissure separated the lingula of the upper lobe. In both instances, the bronchus to the lingular lobe arose as a branch from the main lower lobe bronchus.

Incomplete extra fissures were noted in 46 instances: 21 in the right lower lobe; 3 in the right upper lobe; 2 in the left lower lobe; and 18 in the left upper lobe. In some instances, there was a considerable amount of connective tissue in the incomplete fissure line which was of sufficient extent to cast a shadow in a roentgenogram. These extra fissures would seem to be hereditary in character as was shown by the following incidence. A family of 4 persons (father, mother, and 2 sons) were all autopsied on the same day. The lungs of the mother showed an incomplete right middle lobe fissure with the main fissures complete and no extra fissures. The lungs of the father

showed a complete fissure on the left, an incomplete middle lobe fissure and an incomplete main fissure on the right with an incomplete extra fissure in the upper third of the right lower lobe. Both sons had a fissure pattern exactly like that of the father. It is of interest that of the 21 extra fissures observed in 1,200 right lower lobes, 3 of them should have occurred in the lungs of this father and his two sons.

Azygos grooves were observed 7 times: 5 in the right and 2 in the left upper lobe. This groove is caused by a shelf of connective tissue which supports the vein at its free margin. It is analogous to the grooves made by the large blood vessels leaving the thorax and the inferior vena cava and the portal vein as they enter the thorax. They do not have the same significance, so far as lung structure is concerned, as do the fissures. In one instance, the azygos vein entered directly into the right auricle rather than into the superior vena cava.

A considerable variation in the level of fissures was noted but extreme variations were infrequent. The variations recorded here are those where complete major fissures were present. In the left lung, the apex of the lower lobe was at or below the sixth rib dorsally in 10 instances; at the second rib in 48 lungs; at the first rib 20 times; and formed half or more of the apex of the lung in 12 specimens. In one of this latter group, there was a tuberculous process with cavity formation in the lower lobe in a position which is commonly regarded in roentgenograms as indicative of an upper lobe tuberculosis.

The right middle lobe showed extreme variations in only 9 instances. In 5 cases, the lobe was unusually small, the cephalocaudad-ventral measurement being less than 2 cm. In 4 instances, the lobe was unusually large with the cephalic border being at the level of the second rib ventrally.

Extreme variations in the right lower lobe were observed 10 times; at the first rib dorsally in 2 lungs; at the second rib in 6 lungs; and at or below the sixth rib twice.

SUMMARY

Variations in structure of the lungs observed in 1,200 necropsies are recorded to afford specific information relative to the type and to the frequency of these variations. Pulmonary lobes are entities only where complete fissures exist. Absence of a fissure, in part or as a whole, allows an inextricable enmeshment of pulmonary lobules from adjoining lobes. Incomplete fissure lines often contain a sufficient amount of connective tissue to register shadows on a roentgenogram of the chest. The existence of the numerous variations in pulmonary structure requires that they receive proper recognition in the diagnosing and treatment of pulmonary diseases.

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EXTRAMUCOSAL TUMORS SIMULATED BY GASTRIC CARCINOMA*

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THE increasing number of preoperative roentgen diagnoses of extramucosal intramural gastric tumors can be ascribed to several factors, principally the awareness of the possibility of such a lesion, combined with an improved roentgenographic technique. Nevertheless, it must be stressed that, despite the roentgen criteria which have been set forth for the diagnoses of such tumors, certain intramural adenocarcinomas may produce identical roentgen findings. Moreover, it may be impossible to differentiate the two types of tumor except by pathologic examination of the tissues. However, it is our belief that roentgen differentiation in some cases may be possible.

Thus, the well known roentgen syndrome of a sharply defined intraluminal defect with or without a central crater has been considered pathognomonic of a tumor of extramucosal intramural origin. Since leiomyoma and leiomyosarcoma fulfill the requirements for such tumors, the roentgen criteria for the diagnosis of these tumors are presented. That accurate preoperative differential diagnosis of gastric tumors is desirable is self evident. As Schindler[6] has aptly pointed out, while the surgeon may not be willing to operate upon large infiltrating carcinomas, leiomyosarcoma and certainly leiomyoma have a much more favorable prognosis.

Moore,[3] in his detailed discussion of benign gastric tumors, presented several aspects which he considered to be of diagnostic value. The principal features which he emphasized are worthy of repetition so that they may be evaluated more critically in view of our findings.

1. Benign tumors produce a filling defect which is circumscribed and punched out in appearance, occasionally exhibiting a crater in the dome.
2. This filling defect is usually on the gastric wall, leaving the curvature regular and pliant.
3. While the rugae are obliterated in the immediate area of the tumor, as in inflammatory and malignant conditions, the rugae surrounding the benign tumors are more nearly normal in their arrangement and distribution.
4. These tumors produce little or no disturbance in peristaltic activity, and retention is uncommon except when the lesion is at or near the pylorus. No contraction or spasm of the stomach is associated with such lesions.
5. They are rarely large enough to palpate. Manual manipulation or pressure in order to approximate the gastric walls is essential to demonstrate the mass, particularly in the case of small tumors.

Schatzki and Hawes,[5] in their presentation of extramucosal tumors of the esophagus, formulated the criteria for the diagnosis of similar tumors elsewhere in the gastrointestinal tract. Sahler and Hampton[4] elaborated upon these findings in their discussion of bleeding associated with extramucosal gastric tumors. The latter investigators state that the extramucosal intramural tumors are characterized by the presence of a space occupying, smooth or lobulated defect of the gastric wall. The mass is usually sessile but may be pedunculated and project into the lumen of the stomach. The tumor appears to be extrinsic when viewed in profile but is movable with the stomach when this viscus is manipulated. Except in the region of the tumor

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mass, the mucosal pattern of the stomach is normal. The mucosal folds adjacent to the tumor are pliable. In many cases of extramucosal as well as mucosal tumors, normal folds may be visualized which appear to overlie the gastric defect. These folds, however, are formed by the rugae of the wall opposite to the tumor and not by the surface folds of the lesion itself.

Schatzki and Haines[5] note that normal folds are more commonly seen in extramucosal than in mucosal lesions. They ascribe this to the fact that the irregular surface of the mucosal tumors stands out and obscures the normal folds of the opposite wall. Frequently, the mucosal tumors will present areas of ulceration along with the irregular surface. The surface of an extramucosal tumor, on the other hand, is usually smooth. A definite abrupt angle of varying degree is formed by the tumor with the uninvolved gastric wall. When viewed roentgenoscopically in different positions, the tumor margins present different degrees of sharpness. Traction of the gastric wall by the tumor mass may produce a pseudopedunculated appearance.

Feldman[1] adds the following points as a further means of differentiating between carcinoma and extramucosal tumors. Thus, he feels that carcinoma more commonly affects the orifices, a finding which is rare in benign or malignant leiomyoma. Because of this, obstruction in gastric carcinoma is more common and occurs earlier.

Most of the papers dealing with extramucosal intramural gastric masses stress the importance of searching for and recognizing the presence of an ulcer crater. Ulceration of the mucosa in such cases is attributed to necrosis because of the relative avascularity of the tumor. However, ulceration may or may not be present. Its presence or absence is not of value in distinguishing between benign and malignant tumors. Similarly, the position of the lesion in the stomach is of no differential diagnostic value.

There is no doubt that gastroscopy is of value in the differential diagnosis of such tumor masses, but, as Sahler and Hampton[4] have aptly pointed out, the value of such a procedure is dependent upon the ability of the gastroscopist. The gastroscopist can more accurately judge the condition of the mucosal surface but more certain evaluation of the submucosa is the job of the roentgenologist. The correct diagnosis of an extramucosal intramural leiomyosarcoma in the face of a contrary roentgen diagnosis has been made by Benedict. However, on the other hand, Benedict, as well as Schindler, has reported cases in which the lesion was missed completely or not diagnosed correctly following gastroscopic examination. Benedict believes that there is no way of differentiating a benign from a malignant intramural tumor. In a case of a malignant submucosal tumor, he noted that the mass was larger and the ulceration deeper than in the benign case. Schindler, however, believes that the preoperative diagnosis of leiomyosarcoma of the stomach is in the realm of possibility. In addition to the gastroscopic demonstration of a protruding mass and visualization of the central niche in the tumor, Schindler has stressed the presence of bridging folds which he believes should establish a diagnosis of a submucosal tumor mass. While the preoperative diagnosis of such tumors has been made by gastroscopic means, it is the consensus that further experience is necessary.

The following cases are presented to demonstrate that these criteria, singly or collectively, are not in themselves pathognomonic of an extramucosal intramural lesion.

REPORT OF CASES

Case 1. G. S., a white female, aged sixty, entered the Grace Hospital on January 1, 1944, complaining of weakness and fatigue of four months' duration. A month prior to admission, she noted a streak of bright red blood in her stools. There had been no recent weight loss, anorexia, nausea, vomiting, diarrhea or constipation. Physical examination revealed an elderly asthenic woman. There was slight pallor of the buccal mucous membranes and a smooth

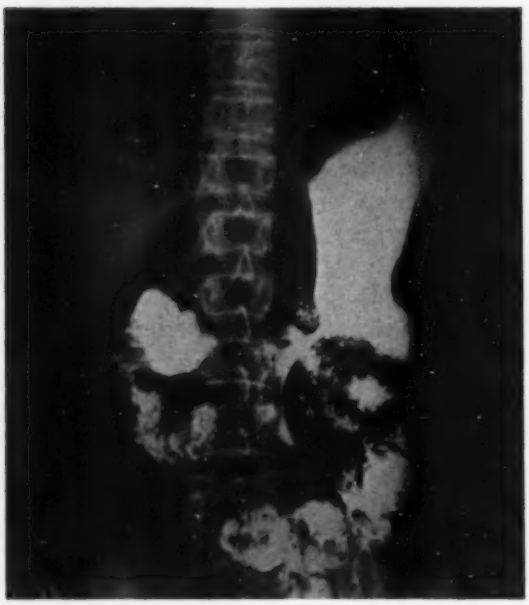

FIG. 1. Case I. The sharply defined intraluminal mass along the greater curvature of the stomach is readily visible. The irregular reticular pattern demonstrated on the original roentgenograms is not well reproduced.

tongue. A slightly tender, movable mass, the size of an egg, was felt in the left upper quadrant. The pertinent laboratory findings at the time of admission were as follows: erythrocyte count, 2,600,000 per cubic millimeter, with 52 per cent hemoglobin; leukocyte count 11,600 per cubic millimeter, with a normal differential count. Gastric analysis showed no free hydrochloric acid; the total acid was 11 units.

Roentgen examination of the gastrointestinal tract on February 1, 1944, showed a smooth, well defined, circumscribed mass approximately 8 cm. in diameter arising from the greater curvature aspect of the stomach (Fig. 1). The mass appeared to be fixed to the gastric wall and apparently had no pedicle. Pressure on the anterior gastric wall produced a translucent filling defect but no ulcer crater was demonstrable in the dome of the tumor mass. No peristaltic waves passed through the base of the lesion. *The mucosal pattern of the surface of the mass presented numerous reticular irregularities.* Roentgenographically, the diagnosis of a gastric leiomyosarcoma was made.

On February 14, 1944, following several blood transfusions, a subtotal gastric resection was done with an anastomosis of the stomach to the remaining duodenum. At operation, there was extensive metastatic involvement of the lymph nodes in the gastrocolic omentum but no gross involvement of the liver. The patient recovered and was discharged on March 1, 1944.

The gross specimen consists of 15 cm. of stomach extending to the duodenum and including the mesentery in which there were several greatly enlarged lymph nodes (1 to 4.4 cm. in diameter). On the greater curvature aspect of the stomach, there was a flattened circular tumor covered with mucosa and extending through the muscularis almost to the serosal surface. The tumor measured 7.2 by 5.5 by 4 cm.

Microscopic examination showed an adenocarcinoma with a definite glandular pattern (Fig. 2). Many of the cells were dilated and filled with pink-staining mucus. Considerable inflammatory exudate was present. No sharp demarcation between the margins of the tumor and the adjacent normal tissue in the submucosal layer. The tumor cells showed extensive infiltration into the submucosa and muscularis.

CASE II. F. S., a female, aged twenty-nine, was admitted to the New Haven Hospital on January 29, 1945. For many years, she had had vague abdominal discomfort after meals. One month before admission, she had several days of general aching which she interpreted as gas pains. These extended over the back and chest and were not related to meals. There was some improvement after antacid and sedative therapy. Roentgen examination of the gastrointestinal tract suggested the presence of a leiomyoma of the stomach. One observer (R.M.L.), because of the previous experience in Case 1, compared the two cases and suggested the diagnosis of gastric carcinoma.

The patient was then gastroscoped on January 25, 1945. Preliminary emptying of the stomach yielded about 3 cc. of mucoid fluid containing free hydrochloric acid and many fresh blood clots. The patient was very apprehensive but the gastroscope was introduced without difficulty on the second insertion; on the first insertion, the tip of the gastroscope presumably became stuck at the tumor. An excellent view of a normal angulus and antrum was obtained. The antrum contained some dark red blood. The gastric mucosa was normal everywhere until the scope was withdrawn to a point about 2 inches below the cardia. Here, the greater curvature toward the posterior

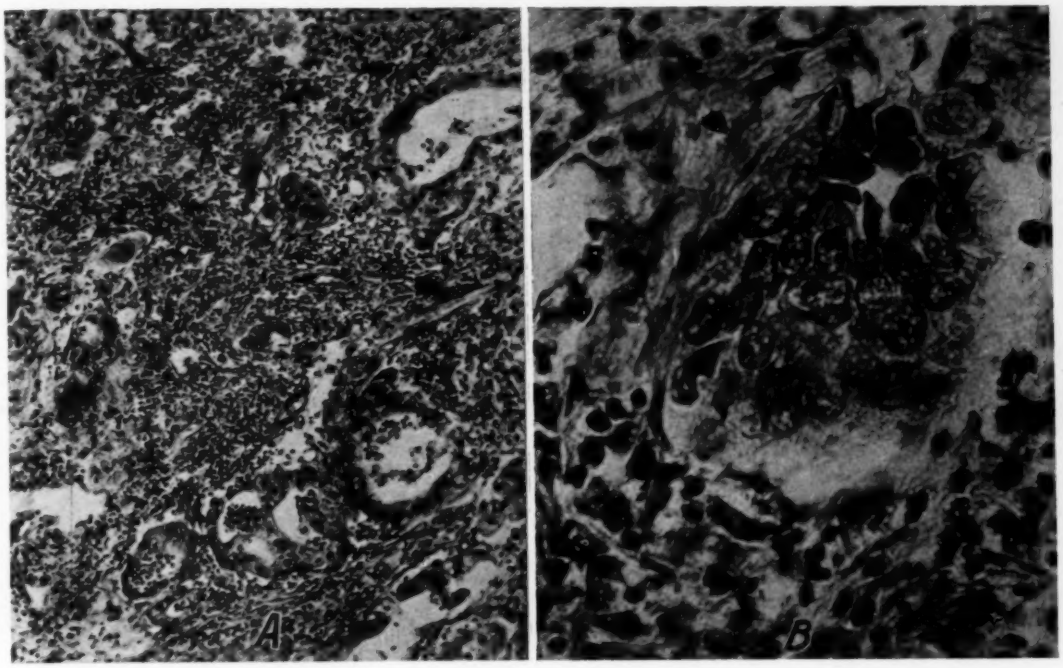

Fig. 2. Case 1. *A*, this section of the tumor shows the acinar arrangement of the adenocarcinoma along with the marked round cell inflammatory reaction (×150). *B*, this demonstrates a collection of tumor cells contained in a blood vessel (×650).

wall seemed to be diffusely pushed up into the lumen; this elevated mucosa appeared normal except in one area where there was a distinct ulcer crater about 1 inch in diameter. The crater had an irregular bleeding strawberry-like surface covered with exudate. Radiating folds were seen extending from the ulcer in all directions. The gastroscopic diagnosis was ulcerated leiomyoma with probable sarcomatous change in the center.

After these examinations, the patient received further medical therapy and gained 5 pounds in the three weeks before admission.

The patient's past history was irrelevant as was her family history. A complete review of systems showed these to be essentially within normal limits. On physical examination, the patient was well developed and well nourished and did not appear ill. Her vital signs were normal and the complete physical examination was entirely within normal limits including careful examination of the abdomen, rectal and pelvic examination.

Laboratory investigation revealed negative serology; erythrocyte count, 3,450,000 per cubic millimeter, with 11 gm. of hemoglobin; leukocyte count, 6,300 per cubic millimeter with 70 per cent polymorphonuclear leukocytes; 24 per cent lymphocytes and 6 per cent large mononuclear cells. The urine was normal and the non-protein nitrogen 26 mg. per 100 cc. The total serum proteins were 6.7 grams per 100 cc.; serum chloride was 103.2 milliequivalents. Gastric analysis of the fasting contents showed 10 cc. of tan mucoid fluid with a 3 plus guaiac reaction, no free HCl, 16 units total acid. Following administration of histamine, 20 cc. of colorless mucoid fluid with 60 units of free HCl and 74 units of total acid were found. In this specimen, lactic acid was present. There was only a trace of blood. Further gastrointestinal roentgen examinations revealed a large filling defect on the greater curvature of the stomach on the posterior wall measuring approximately 6 cm. in its greatest diameter with evidence of a large crater in the center of the tumor mass (Fig. 3). There did not seem to be an abnormal mucosal pattern down to the deformed area. Peristalsis appeared normal but it was not clear whether or not peristalsis passed directly around the tumor area (Fig. 4). The remainder of the examination was essentially

FIG. 3. Case II. The well demarcated intraluminal defect with central ulceration along the greater curvature of the stomach is shown.

normal. No barium enema examination was done. The roentgen diagnosis was leiomyosarcoma of the stomach.

On February 5, 1945, after a preliminary transfusion of 500 cc. of whole blood, a subtotal gastrectomy of the Billroth I type was done by Dr. Samuel C. Harvey. The stomach was freely movable and the liver showed no involvement. There were no large lymph nodes apparent aside from two or three tiny ones in the greater omentum about the greater curvature of the stomach. The gastrectomy was carried out well above the tumor. The patient withstood the procedure well, having received parental fluid and another transfusion of 500 cc. during the procedure.

The frozen sections suggested a benign tumor. The gross specimen consisted of the distal portion of the stomach. Upon the greater curvature in the posterior portion, there was a hard firm lesion. The lesion measured 6 cm. in diameter with an ulcer in the center about 1 cm. in diameter (Fig. 5). The serosa over the lesion was indented and constricted. The rest of the stomach mucosa was smooth and regular with a normal rugal pattern. In the mesentery, some hard firm lymph nodes are felt, the largest being 1 by 2 cm.

Microscopic examination of sections from the edge of the stomach to the center of the ulcerated lesion revealed normal intact mucosa at the edge of the stomach (Fig. 6). No evidence of tumor was present at the edge of the section. As the section was followed medially, the mucosa remained intact. However, in the underlying submucosa, some cells were seen infiltrating throughout the edge of the section. The cells had large dark staining nuclei and a large amount of clear colloid cytoplasm. Mitotic figures were present in these cells. Another section showed an intact epithelial lining pushed up by a diffuse growth of tumor cells. These cells had irregularly shaped nuclei which stained deep purple; a small amount of pale pink cytoplasm was present and there was much clear vacuolated mucoid and colloid material surrounding this infiltration. Occasionally, the cells were grouped together to form acinar and glandular structures. These cells infiltrated down into the underlying muscular areas and were seen present in all of the layers of the stomach. Sections of the regional lymph nodes revealed carcinomatous cells to be present lying on the external surface of the nodes outside of the capsule and also within the capsule lying in the sinusoids at the edge of the lymph nodes. The lymph node structure, however, still maintained much of its normal pattern and lymphoid follicles were seen to be

FIG. 4. Case II. The oblique projection demonstrates the location of the lesion on the posterior wall of the stomach.

present. The infiltration with tumor cells was seen to be present in all the lymph nodes examined. The pathological diagnosis was colloid adenocarcinoma with lymph node involvement.

The patient's postoperative course was uneventful and she was discharged on February 18, 1945. A follow-up examination in December, 1945, showed no clinical signs of recurrence.

Case III. E. R., a white male, aged seventy-six, was admitted to the Grace Hospital on January 29, 1946, complaining of continuous dull cramp-like umbilical pain and constipation of one month's duration. The pain was associated with nausea and vomiting occurring a few minutes after eating. The vomitus was yellow in color. There had been no recent weight loss, anorexia, melena or jaundice. Some nocturia and difficulty in starting the urinary stream had been present for the past six years.

Physical examination revealed a well developed, well nourished elderly male, looking younger than his stated age. There were dilated abdominal veins. One of several examiners recorded a rather firm, poorly defined mass along the greater curvature aspect of the stomach. Hepatomegaly was also observed but the inferior border of the liver could not be definitely delineated. The prostate was diffusely enlarged and somewhat firmer than normal. The pertinent laboratory findings on admission were as follows: erythrocyte count, 2,000,000 per cubic millimeter, with 53 per cent hemoglobin; leukocyte count, 14,200 per cubic millimeter, with a normal differential count. Gastric analysis showed no free hydrochloric acid after histamine. The stools were guaiac positive for occult blood.

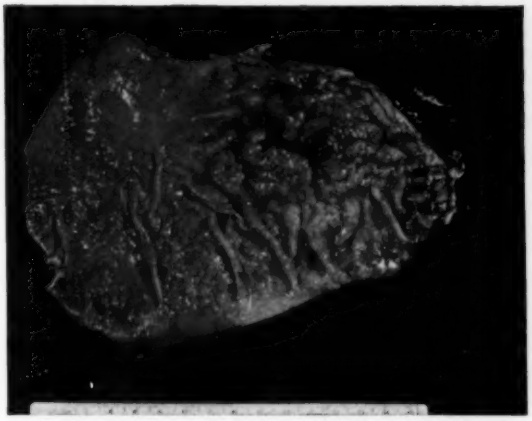

Fig. 5. Case II. Gross specimen of the stomach removed at operation showing the irregular heaping up of the mucosa in the region of the tumor. The ulcer crater is well shown.

Roentgen examination of the gastrointestinal tract on February 6, 1946, showed a smooth, well circumscribed oval mass approximately 5 by 4 cm. along the greater curvature aspect of the stomach (Fig. 7 and 8). *A reticular pattern of the mucosa covering the surface of the tumor was noted* (Fig. 9). The duodenal cap was intact. Several duodenal diverticula were also noted. This lesion was considered to be a gastric adenocarcinoma. However, several competent

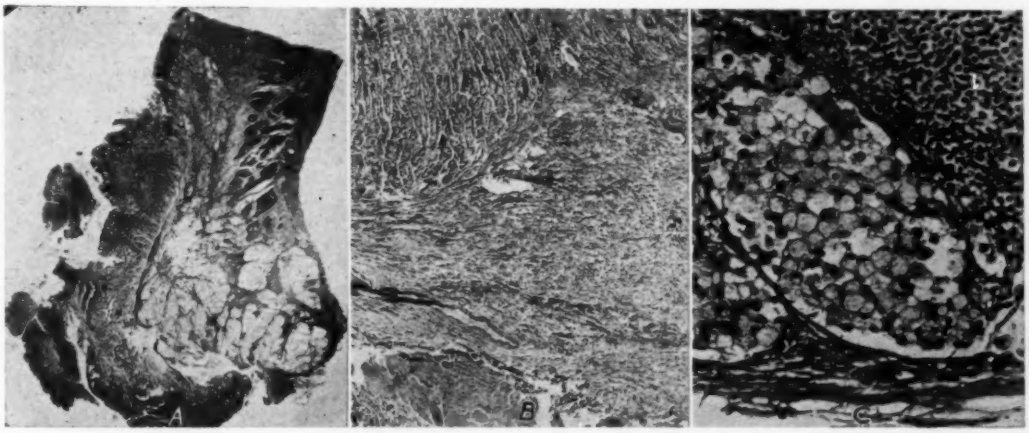

Fig. 6. Case II. *A*, this shows submucosal infiltration of the tumor with extension into the mucosa in one area (×33⅓). *B*, this shows the fairly sharp demarcation between the tumor and normal surrounding tissue (×6½). *C*, this demonstrates the large mucus containing cells with eccentric signet-ring nuclei in a vascular channel in a regional lymph node (×350).

FIG. 7. Case III. The site of the intraluminal tumor on the greater curvature aspect of the stomach is well shown.

observers seriously considered the possibility of a leiomyosarcoma of the stomach.

The barium enema showed an area of extrinsic pressure involving the left lateral aspect of the upper rectum with narrowing in the region of the rectosigmoid. In several roentgenograms, a small projection was noted simulating an ulcer niche on the left anterolateral wall of the rectum.

The patient developed bloody diarrhea, and proctoscopy showed the rectum to be hyperemic and edematous. Approximately 20 cm. above the mucocutaneous junction, a granular bleeding area was noted. On March 1, 1946, following numerous blood transfusions, an exploratory laparotomy was done. At operation, a hard mass, seemingly intramural, the size of an egg, was noted in the region of the pylorus. A soft mass was observed in the rectosigmoid area with many adhesions. The liver was greatly enlarged, and studded with numerous nodular metastases. The patient ran a continuously retrogressive course and died on March 4, 1946.

At autopsy, a large irregularly lobulated elevated tumor approximately 8 cm. in its longest diameter was found on the anterior surface of the greater curvature aspect of the stomach. The surface of the tumor was polypoid and cauliflower-like in appearance. Although normal mucosa could be noted extending up into the margins of the tumor mass, no satisfactory mucosal pattern was observed overlying the tumor itself.

Microscopic examination showed an adenocarcinoma without definite glandular arrangement (Fig. 10). The predominant cell was fairly large, polyhedral in shape with a large, dark staining nucleus and occasional mitoses. In some sections, there was a suggestion of glandular formation but the adenomatous structure was not completely reproduced. Essentially, the same findings were seen in the sections of the liver metastases.

DISCUSSION

In the cases which have been presented,

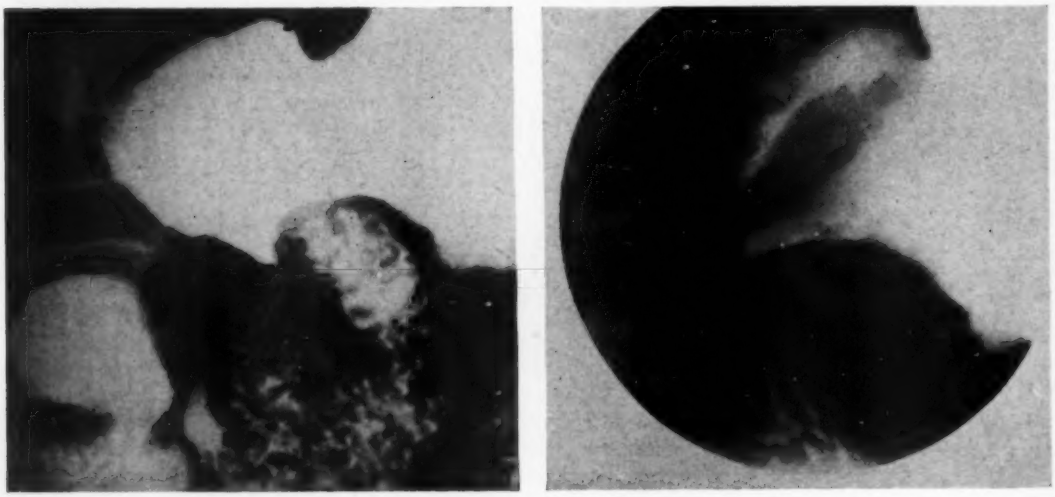

FIG. 8. Case III. Spot roentgenograms showing greater detail of the lesion.

an adenocarcinoma of varying histopathologic structure was proved to have invaded the gastric wall producing an endogastric mass which simulated an extramucosal tumor. Clinically, the outstanding findings associated with these lesions were: (1) an upper abdominal mass; (2) epigastric pain; (3) gastrointestinal hemorrhage associated with anemia. The occurrence of an extensive colloid adenocarcinoma in a female, aged twenty-nine, is in itself unique. Nausea and vomiting were recorded in one of the cases. The weight loss in each was moderate and none of the patients considered it of consequence. None of the clinical features or laboratory findings was of value in the main problem confronting the observer of determining whether the mass was benign or malignant.

These carcinomas fulfill all of the roentgen criteria set forth in the literature for the diagnosis of extramucosal tumors. That these criteria are not entirely pathognomonic of the latter is amply demonstrated by the cases cited. While it is reasonable to suspect a tumor of extramucosal origin when a sharply defined, rounded filling defect is noted, the diagnosis in such cases is based on probability alone. The frequency of sarcoma as compared with carcinoma of the stomach is said to be only 1.100. However, adenocarcinomas producing roentgen

Fig. 9. Case III. Spot roentgenogram illustrating the reticular pattern seen much more clearly on the original film.

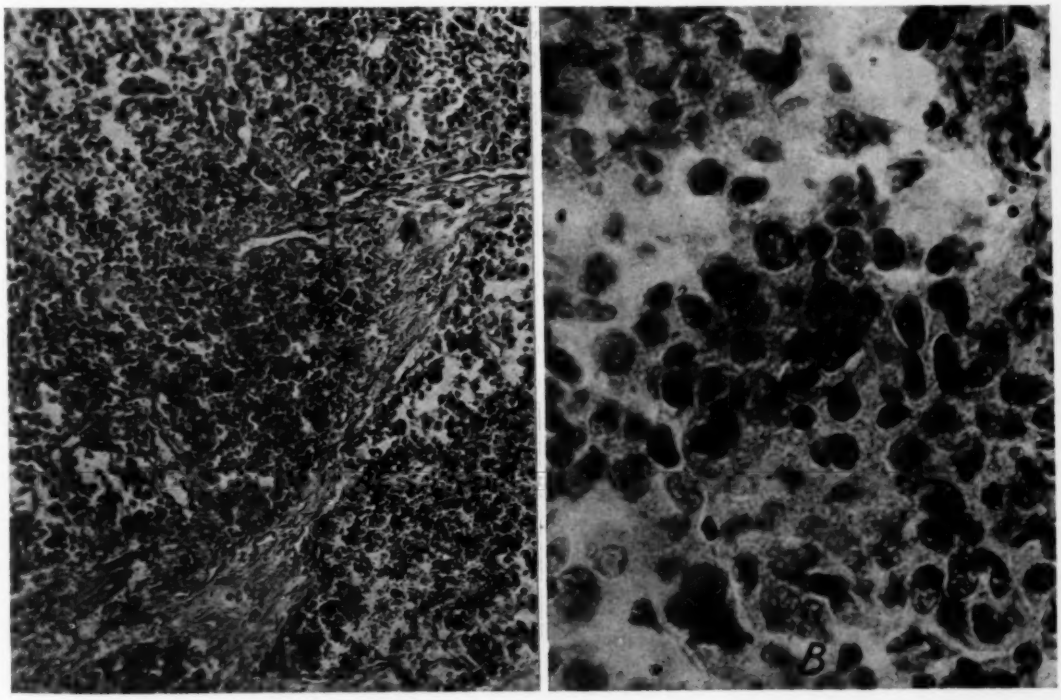

Fig. 10. Case III. *A*, section of tumor showing absence of glandular configuration (×150). *B*, high power magnification showing cellular detail with deep staining nuclei and mitotic figures (×650).

defects such as have been described above are also infrequent. Gastric carcinoma with preponderant submucosal intramural infiltration can and does simulate extramucosal tumor. Roentgen differentiation between these two types of tumors may not always be possible.

Cautioned by the previous experience of Schatzki and of Templeton, specific attempts were made to obtain roentgen pattern studies of the tumor surface by means of the mucosal relief technique. On the mucosal relief films, a coarse irregular reticular pattern was noted. The barium overlying the well defined endogastric tumor masses was arranged in an irregular polyhedral network. In many ways, it was similar to the pattern produced by a slightly moistened sponge upon a dry blotter. At first, the examination of the histopathologic sections seemed to indicate that the reticular pattern was caused by the irregular submucosal infiltration by the tumor with resultant heaping up and distortion of the overlying gastric folds and retention of barium in the interstices. However, subsequent critical examination of many other histopathologic sections demonstrated that the reticular pattern could be formed by one or by a combination of features. In Case I, marked diffuse destructive infiltration of the tumor into the mucosa could be demonstrated. In many places, the mucosa was entirely replaced by the well differentiated tumor cells. Normal orientation of the cells especially in the submucosal area was lost. In other areas, the extensive mucosal and submucosal transformation was accompanied by a marked inflammatory reaction. In these areas, numerous small ulcerations lying beneath, and adjacent to, an overlying inflammatory exudate could be seen. In Case III, the microscopic sections demonstrate extension of the anaplastic tumor cells into the serosa with involvement of the pancreatic capsule. In addition to the marked mucosal extensions of the tumor, many other areas of the overlying hyperplastic mucosa showed areas of localized destruction and ulceration.

In Case II, a combination of hypertrophic gastritis and infiltration of the mucosa by well differentiated tumor cells was noted. Abnormal changes severe enough to produce nodulation and irregularity of the rugae rarely occur alone, but as Templeton[7] points out, such changes are not uncommon in association with certain forms of carcinoma. When such changes are found in association with malignancy, it is obviously impossible to distinguish the carcinomatous from the inflammatory process. Because of the unique occurrence of this tumor, the type of cell produced, and the configuration of the mass in the roentgen studies, portions of this malignancy were implanted into the anterior chamber of an eye of a guinea pig in order to observe the cellular nature and the activity of this malignancy.

Thus, in evaluating the surface of the tumor, so far as it is related to the irregular pattern which was demonstrated during the roentgen studies, several conclusions can be reached. In this group of cases, abnormal changes severe enough to produce nodular irregularities and enlarged stiffened rugae overlying a localized endogastric mass were caused by irregular mucosal and submucosal proliferation and infiltration by tumor cells. This resulted in polypoid elevation of varying height. While in all of the cases mucosal infiltration was found, only Case I and Case III showed macroscopic as well as microscopic ulceration of the mucosal surface. The macroscopic changes were only recorded after the review of the pathologic specimens, the roentgenographic studies and the repeated microscopic examinations. Previously, the macroscopic ulcerations in these cases had been overlooked. Some of the verrucous granular ulcerations and fissures were associated with varying degrees of tissue degeneration. In Case II, the gross appearance of the mucosa overlying the tumor excluding the site of the large crater, resembled a hypertrophic nodular gastritis.

The reticular pattern demonstrated by means of roentgen mucosal relief studies is

no doubt produced by the irregular nodulation and mucosal elevations projecting into the gastric lumen. The nodulation can be caused by either mucosal or submucosal infiltration, or a combination of both factors. Retention of barium in the depressions and irregular fissures especially with marked compression produces this bizarre roentgen pattern. By means of compression, the folds on the opposite gastric wall are obliterated. In addition, the opposite wall is thus employed to retain barium in the surface irregularities of the tumor.

At the present time, it is our opinion that the reticular pattern demonstrated on the surface of a sharply defined endogastric mass does not differentiate between leiomyosarcoma and carcinoma since diffuse infiltration of the gastric mucosa by the former has been reported by other observers. In addition, gastroscopists have also reported nodulation of the tumor surface in leiomyosarcomas. However, when such a roentgen pattern on a tumor surface is present, it may serve to differentiate malignant from benign tumor masses. The presence of the reticular pattern would militate against the diagnosis of a benign lesion because the submucosal infiltration in such tumors is regular and sharply circumscribed. The one possible exception to this is the rare occasion of tumefactive localized polypoid hypertrophic gastritis.[2]

Because of the small number of cases in our own personal experience, we do not wish to make any dogmatic claims for the reticular pattern. It is being reported so that other investigators may search for it and thus determine its frequency and significance.

CONCLUSIONS

1. The roentgen criteria for the diagnosis of extramucosal intramural gastric tumors are reviewed.

2. Evidence is presented to demonstrate that the roentgenographic criteria previously proposed are not satisfactory for the diagnosis of extramucosal intramural gastric tumors.

3. Three cases of intraluminal gastric carcinomas which simulated tumors of extramucosal origin are presented.

4. An irregular reticular pattern following relief mucosal studies of the gastric masses is described. The significance of this reticular pattern as a further adjunct in the diagnosis of gastric masses is discussed.

We wish to express our gratitude to Dr. A. J. Mendillo, Dr. Walter I. Russell and Dr. Alphonse Gencarelli for their hearty cooperation in the preparation of this paper. In addition, we wish to thank Dr. C. J. Bartlett and Dr. Stanley Durlacher for their invaluable assistance in the review of the pathologic material.

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LOW BACK PAIN ASSOCIATED WITH VARICES OF THE EPIDURAL VEINS SIMULATING HERNIATION OF THE NUCLEUS PULPOSUS*

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HERNIATION of the nucleus pulposus of the lower lumbar spine is a common cause of persistent low back pain. Confirmation of the diagnosis by myelography may be necessary, particularly when the clinical findings are doubtful. The demonstration of a defect in the column of pantopaque with elevation, compression or obliteration of the dural axillary pouch on the affected side is considered diagnostic of an extruded nucleus pulposus. The frequency of this condition should not, however, obscure the fact that other less well known mechanisms may produce similar complaints and roentgenographic pictures.

We have lately observed 3 patients who had low back pain associated with varices of the epidural veins. One was diagnosed clinically and myelographically as having a herniated disc of the lumbosacral spine. A second patient with persistent low back pain presented a somewhat atypical clinical syndrome, but myelography disclosed a persistent filling defect in the pantopaque column diagnosed as a herniated disc. The third patient was operated on immediately after admission to the hospital without myelography because his clinical history and physical findings were typically those of a herniated disc. Relief of pain followed operation in all 3 patients, the surgical procedure consisting essentially of decompression.

CASE REPORTS

CASE 1. H. G., male, aged thirty-seven, fell on his left side six months before admission and complained of severe low back pain radiating down the outer side of his left leg to his toes one hour after the accident. The pain soon became intermittent and was aggravated by coughing and sneezing. Numbness of the left foot was noted occasionally. He was first treated by traction and a plaster body jacket, then by a spinal brace and massage. The pain became so intense and persistent that he was bedridden for two weeks before he entered the hospital.

Roentgenographic examination of the lumbosacral spine was negative on two occasions. The lumbosacral interspace was narrowed.

Myelography using 3 cc. of pantopaque revealed free flow of the oil through the lumbar spinal canal. On the left side of the column at the level of the interspace between the fifth lumbar and first sacral vertebrae a persistent indentation obliterating the axillary pouch was noted. This was reported as a herniated disc.

Examination of the cerebrospinal fluid showed normal manometric responses. The total protein content was 48 mg. per 100 cc. The colloidal gold curve and the Wassermann reaction were negative.

The preoperative diagnosis was herniation of the nucleus pulposus between the fifth lumbar and first sacral vertebrae towards the left side.

At operation (Dr. Leo M. Davidoff) there were no abnormal findings in the interspace between the fourth and fifth lumbar vertebrae. On exploration of the interspace between the fifth lumbar and first sacral vertebrae a very marked degree of venous congestion which bled freely was encountered. Thorough exploration of this interspace showed no evidence of a herniated disc. The dura was opened after the bleeding had been brought under control with fresh muscle placement and no evidence of intraspinal projection of any tumor or underlying disc was seen. The anterior dura seemed spread over a boggy surface which was soft and fluctuant. Pressure on it did not produce any bleeding around the sides of the dura, thus eliminating any extravascular accumulation of blood which might have resulted from the

* From the Radiologic Service of M. G. Wasch, M.D., and the Neurosurgical Services of L. M. Davidoff, M.D., and I. M. Tarlov, M.D., The Jewish Hospital of Brooklyn, Brooklyn, N. Y.

original exploration for the disc. An aspirating needle was inserted through the anterior dura into this boggy mass and fresh blood was withdrawn freely. We were thus convinced that there were varicosities external to the anterior portion of the dura and thought they might be responsible for the deformity in the pantopaque shadow. The patient was not subjected to further operative manipulation, and was discharged relieved of his severe pain. There was slight residual pain in his left leg.

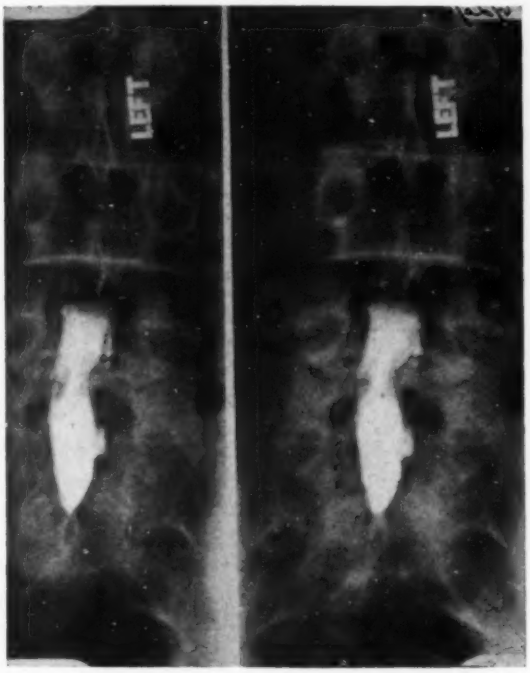

FIG. 1. Case I. Spot roentgenogram with the patient in the erect posture reveals a filling defect on the left side of the column of pantopaque between the fifth lumbar and first sacral vertebrae. A smaller defect is present on the right side of the oil column.

CASE II. M. M., male, aged fifty-seven, first complained of a sharp pain in his right hip five months before admission to the hospital after lifting a heavy weight. A few days later the pain radiated down to the right ankle. He was placed in Buck's extension without relief.

Physical examination revealed diminution of the knee and ankle jerks on the right side. No pathologic reflexes were elicited, nor were any definite sensory changes identified. The radiation of the pain was considered as inconsistent with the presence of a herniated disc and conservative treatment was recommended.

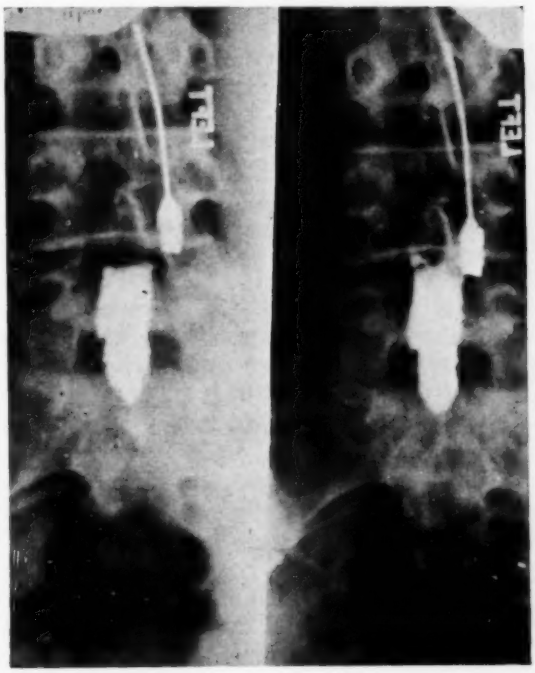

FIG. 2. Case II. Spot roentgenogram with the patient in the erect posture reveals a crescentric filling defect in the left side of the pantopaque column between the fifth lumbar and first sacral vertebrae. The axillary pouch on the left side is obliterated.

He was readmitted three months later because of the increasing and unremitting severity of the pain, which involved the right hip and sacroiliac region and radiated to the dorsum of the right foot. Physical examination showed absence of the right ankle jerk and there was weakness in dorsiflexion of the right foot. No increase of pain was noted on flexion or extension of his back. It was the impression of the neurosurgeon that the findings were not sufficiently characteristic to warrant the diagnosis of a herniated disc.

Examination of the cerebrospinal fluid showed normal manometric responses. The total protein content was elevated to 76 mg. per 100 cc., and a trace of albumin was present.

Roentgenographic examination of the lumbosacral spine showed slight hypertrophic changes in the lower lumbar vertebrae and narrowing of the lumbosacral interspace.

Pantopaque myelography with 3 cc. of oil revealed free flow from the caudal sac to the cisterna magna. At the interspace between the

fifth lumbar and first sacral vertebrae there was a persistent shallow indentation on the right side of the pantopaque column which was considered consistent with the presence of a herniated disc.

In view of the severe persistent pain and the myelographic findings operation was performed (Dr. I. M. Tarlov). The interspace between the fifth lumbar and first sacral vertebrae was exposed and no herniation of the nucleus pulposus could be demonstrated. The nerve root on the right side was in its normal position, but was crossed by a very large vein which was over 0.7 cm. in diameter with the patient breathing quietly. The vein rose from under the lamina of the fifth lumbar vertebra, crossed the nerve root and vanished beneath the first sacral lamina. Mesial to and slightly above this single varix was a bunch of lesser varices varying in size from approximately 2 mm. to over 6 mm. in diameter pressed against the dura laterally and dorsally. These extended around the dura and passed from view in front of the anterior aspect of the dura. The varicosities extended beneath the sacrum even after 1 cm. of its superior rim had been removed. The nerve root between the fourth and fifth lumbar vertebrae was exposed and no abnormality noted. With the cooperation of the anesthetist the patient was made to cough and to breathe rapidly and heavily. During the period of straining the varices became turgid and seemed to dilate visibly while the strain was maintained.

In view of the extent of the varicosities and the thinness of their walls it was considered unwise to attempt either cauterization or clipping.

The patient was discharged relieved of his pain.

CASE III. J. C., male, aged thirty five, twisted his lower back about eight years ago and felt a sharp pain radiating transversely from the right to the left side. After his back was strapped the pain subsided in about one week, and recurred one year before he was admitted. The pain was intermittent, varying from slight to severe, and was worse in the moring on arising. One month before admission he again twisted his back and complained of severe pain radiating from the lower back down the left leg. The pain, which was intensified by coughing and sneezing, was accompanied by tingling and numbness of the left leg. Polyuria was noted during the latest episode.

Physical examination revealed pain on pressure over the fifth lumbar vertebra. The pain decreased somewhat on forward bending. In the erect posture the paravertebral muscles were spastic and there was limitation of motion on anterior, posterior and lateral bending. The motor power of the left leg was decreased and the left lower extremity was hypotonic. Lasègue's sign was positive on the left side. The left thigh and calf were 2 cm. less in circumference than the right. Hypesthesia was present over the posterior and mesial aspect of the left leg and the left big toe. No pathologic reflexes were elicited. The knee and ankle jerks were equal and active.

Examination of the cerebrospinal fluid revealed normal manometric responses. The total protein content was elevated to 111 mg. per 100 cc. The Wassermann reaction and colloidal gold curves were normal.

The clinical syndrome was believed so characteristic of a herniated disc between the fifth lumbar and first sacral vertebrae that pantopaque myelography was considered unnecessary.

At operation (Dr. I. M. Tarlov) the intervertebral space between the fifth lumbar and first sacral vertebrae was clearly exposed and no bulge was noted. It was quite certain that no herniation of the intervertebral disc was present. However, a large varicose epidural vein was seen coursing vertically across the fifth lumbar nerve root on the left side. Its diameter was estimated to be from 0.5 to 1 cm. A small amount of the sacral lamina overlying the varix was removed, but it was considered unwise to try to expose its entire length. The wound was closed without attempting to obliterate the varix by cauterization because of the thinness of its wall.

The patient was discharged relieved of pain.

DISCUSSION

All 3 patients in this group had histories of trauma preceding the onset of low back pain. The pain, which was intensified by coughing and sneezing in 2 patients, was usually intermittent and radiated down the leg on the affected side. On occasions the intensity and the duration of the pain was prolonged and severe. Changes in the ankle and knee jerk reflexes were encountered in 2 patients, and 2 had atrophy of the leg and thigh muscles on the affected side. The spinal fluid total protein content was ele-

vated in 2 patients and close to the upper limit of normal in the third. The colloidal gold curves and Wassermann reactions were normal as were the manometric spinal fluid measurements.

Direct roentgenographic examination of the lumbosacral spine was not diagnostic, although 2 patients had narrowing of the lumbosacral interspaces. Pantopaque myelography revealed defects diagnosed as herniated discs in the 2 patients so examined. Both were found at the interspace between the fifth lumbar and first sacral vertebrae.

It was of considerable interest to observe the changes in the degree of turgescence and distention of the epidural varices in the second case when the patient was caused to strain. No doubt strain during exertion produces similar changes which may well account for the exacerbation of symptoms while coughing, sneezing or straining.

The epidural veins in which the varices were encountered belong to the primary system of veins which drains the spinal column and its adjacent musculature and the meninges.[7] This system, which is not accompanied by arteries and is without valves, is formed by large plexuses within and around the spinal column extending the entire length of the spine. The epidural veins, which receive tributaries from the vertebrae and the spinal cord, are part of the internal vertebral plexus lying between the dura mater and the vertebrae. The intraspinal plexuses course in a vertical direction as four large longitudinal veins, two in front and two behind the spinal cord forming anterior and posterior groups. The anterior internal plexus consists of large veins on the posterior surfaces of the vertebral bodies and the intervertebral fibrocartilages to either side of the posterior longitudinal ligament. The posterior internal plexuses are placed to either side of the midline in front of the vertebral arches and the ligamentum flavum, and communicates with the posterior external spinal plexus of veins by channels passing through those ligaments. The anterior and posterior internal vertebral plexuses communicate with one another freely through a series of venous rings one opposite each vertebra. The internal and external venous plexuses anastomose freely with each other, terminating in the intervertebral veins which accompany the spinal nerves through the intervertebral foramina.

This system of veins has been brought into clinical prominence recently by the outstanding work of Batson, who demonstrated its role in the spread of carcinomatous metastases from the prostate to the brain without pulmonary involvement. Although the existence of the system has long been known, it remained for him to evaluate its clinical importance by his roentgenologic investigations.[1,2,8]

Varicosities of the pial veins are known, the study of Globus and Doshay[6] being one of the most complete. These are usually found on the dorsal surface of the spinal cord subdurally and have been ascribed to obstruction to the return flow of blood at a higher level in the spinal veins, such as might be associated with extramedullary cord tumors, and with venous obstruction from a swollen spinal cord, a narrowed vertebral canal or an adhesive process of the membranes.[4] This type of venous dilatation is secondary, and usually disappears after the obstruction has been removed. Dilatations of the spinal pial veins may occur as true congenital dilatations which may result in angiomas.

The roentgenographic appearance of dilated pial veins[5] differs from that of epidural varices considerably. Pial veins are enveloped by the pantopaque, producing channel-like radiolucent shadows where the opaque oil is displaced by the dilated vein or veins. This appearance may vary from time to time, depending on the degree of dilatation as well as the number of channels open at the time of examination. Epidural varices may produce a myelographic appearance which cannot be distinguished from that associated with protrusions of the nucleus pulposus. This is readily understood if it is recalled that the effect of the

epidural varix on the pantopaque column is indirect, being that of a mass impinging either laterally or anteriorly on the column of pantopaque through the intact dura. The patients reported here had varices in close apposition to the nerve roots, pressing on the affected nerves much in the same way as a protruded nucleus pulposus. The mechanical effects of such pressure is reflected in the clinical syndrome which simulates that of a protruded disc.

The only other case report of an epidural varix in the available literature is that of Cohen,[3] who states that similar cases have been described by Dr. Jefferson Browder of Brooklyn and Dr. James Greenwood of Houston, Texas. The clinical syndrome in his patient was that of a herniated disc of the lower lumbar spine. The varix was not directly visualized at operation, much the same as occurred in the first patient reported here.

SUMMARY

Three patients with low back pain associated with varices of the epidural veins in the lower lumbar spinal canal are reported. The similarity between this condition and herniated intervertebral discs, so far as their clinical and roentgenologic manifestations is concerned, is discussed.

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Vol. 57, No. 6

IVORY VERTEBRA ASSOCIATED WITH LIPOMA OF THE SPINAL CORD*

CASE REPORT

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THE nature and causative factors of "ivory vertebra" have been a stumbling block to investigators for a long time. It will probably be necessary to wait until the true nature of calcium metabolism is ascertained before the peculiar changes in "ivory vertebra" are more clearly understood.

Souques, Lafourcade and Terris[7] termed the increased density in an isolated vertebra with normal size and contour and with no changes in the intervertebral disc "ivory vertebra" and considered these changes a symptom syndrome rather than a disease entity.

Ochsner and Moser[6] in 1933 reported such a case and gave a résumé of the literature up to that time. They briefly but aptly reviewed the differential diagnosis of the various diseases that can produce localized increase in density of a vertebra. The blood changes will aid in the diagnosis of myelogenous leukemia, presenting localized sclerotic changes in the vertebra. In tuberculous spondylitis, the involvement of the disc and a paravertebral abscess aid materially in arriving at a diagnosis. Negative serology and no response to antiluetic therapy are factors that usually rule out lues with vertebral changes. The changes in the vertebrae following typhoid fever involve the intervertebral disc and the process is destructive in nature according to Keith and Keith.[5]

Localized condensing osteitis can occur in several diseases and many cases of "ivory vertebra" reviewed were osteitis deformans of Paget, while a few were typical of osteoplastic metastasis. Hultén's[4] case of Hodgkin's disease of the vertebra added to the difficulties in classification.

The extensive investigations of Bársony and Schulhof[1] led these authors to believe that the majority of such cases were local manifestations of Paget's disease. In Hallermann's[2] observations of Paget's disease the most frequent changes were a thickening of the peripheral and a thinning of the central portions of the bodies of the vertebrae. Some had a fine porous atrophy of the entire vertebral body. Ochsner and Moser believe that some of Hallermann's illustrations resemble primary hemangioma rather than "ivory vertebra."

Osteopoikilosis, marble bones, and diffuse osteosclerosis never involve a single vertebra or restricted area. In the following case the clinical symptoms were all due to the cord lipoma and its neurologic manifestations.

CASE REPORT

A. G., a white male, aged thirty-three, was inducted into the Army two and one-half years ago. Sixteen years ago he fell from a height of 20 feet and landed on his back. He has had a backache ever since, but the pains grew worse in the last two years. He lost 20 pounds in the past eighteen months. There was a history of transient blindness eight years ago. No history of bladder or rectal difficulties. He now claims he is getting weakness in his legs and can no longer walk a straight line. He also noted that he perspires profusely only on the right side. There is no history of meningitis or other infections of the nervous system.

Physical examination limited to consideration of spinal cord disease was as follows: There was pain to percussion over the vertebral processes of second to sixth dorsal vertebrae and an area of atrophy of the skin in the same region was noted. Minimal atrophy and marked fibrillation of the rhomboid muscles was also noted at this time. There was hyperhydrosis over the

* From the X-Ray Department, Hammond General Hospital, Modesto, California.

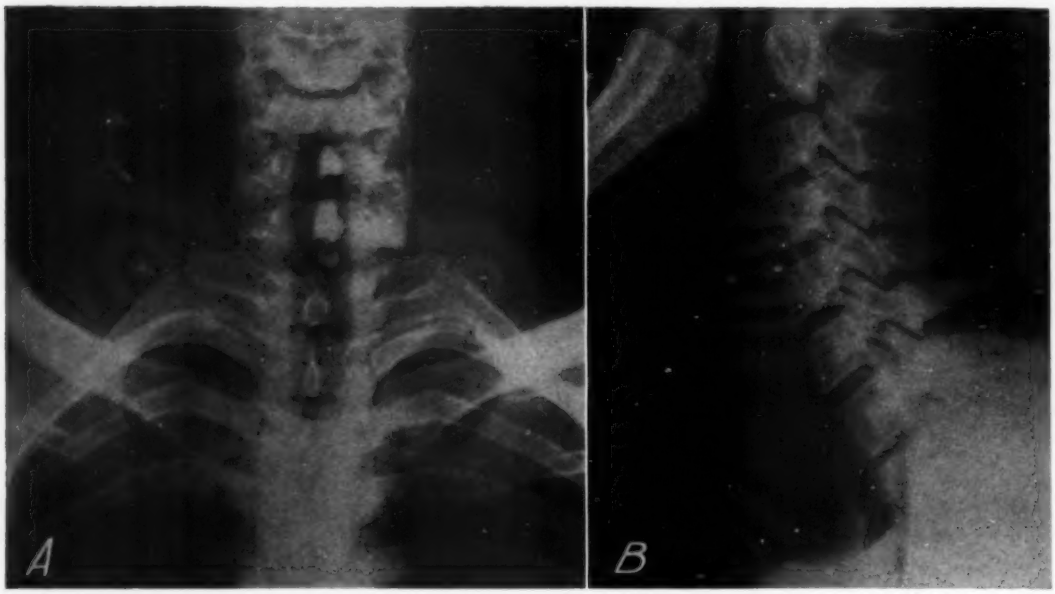

Fig. 1. Anteroposterior (*A*) and lateral (*B*) views of cervical spine demonstrating condensing osteitis posterior body of the sixth cervical vertebra and laminae and spinous processes of the sixth and seventh cervical vertebrae.

right side of the body, especially in the right axilla. A small area of hypesthesia in the right fourth to fifth thoracic dermatomes was found. The abdominal and cremasteric reflexes were absent on the left side. The knee jerks and ankle jerks were more active than the biceps and triceps on both sides. The patient had some difficulty with trick phrases of speech. There was no obvious evidence of cerebellar disease. Both optic discs were within normal limits, as were the toe signs. A weakness of both legs was noted, more marked on the left side. The laboratory findings were essentially normal except for a spinal fluid protein of 76.

Fig. 2. Posteroanterior cervical myelogram shows irregular defect on left side extending from the fifth to the seventh cervical vertebrae. The opaque material used was pantopaque.

Roentgenograms of the cervical spine demonstrated a diffuse but marked increase in density of the posterior portion of the bodies of the sixth and seventh cervical vertebrae and their laminae and spinous processes. The contour of the vertebrae of the cervical spine and the intervertebral spaces appeared normal. There was no evidence of bone infection or destruction. Cervical myelograms showed an irregular defect on the left side from the fifth cervical to the first dorsal. Diagnosis of cord tumor was made and the possibility of metastasis of an osteoplastic nature, though rare, had to be considered. The general condition of the patient and lack of symptoms directly attributable to the bone changes of the lower cervical vertebrae favored the consideration of a benign tumor. A skeletal survey failed to show any bone changes.

The patient was given a Certificate of Disability Discharge from the Army in June, 1945. In July, 1945, he submitted to surgery and a personal communication from his surgeon corroborated the above findings.* A large irregular lipoma was found occupying the left side of the lower cervical cord. The tumor appeared very adherent in its mid-portion and appeared to be derived from the medullary substance. Great difficulty was experienced in removing the laminae of the sixth and seventh cervical vertebrae because of the hardness of these bones. The incision had to be enlarged to include the removal of the laminae of the first thoracic vertebra and this bone also was extremely hard and difficult to remove.

The pathologic report revealed an irregular lipoma with several deposits of hemosiderin indicating previous hemorrhage. It showed no undue degree of growth activity. The bone removed showed no evidence of recent or old infection or of metastasis. The possibility of nutritional changes as a causative factor in producing the sclerosing osteitis in this case must be considered, for the blood supply to the laminae, as well as the remainder of the involved vertebrae, was interfered with by the extreme degree of pressure caused by the tumor. Check-up roentgenograms of the cervical and upper dorsal spine showed no further bone changes.

Clinically, the patient now has only slight pain between the scapulae, and sensory and motor functions are entirely normal.

The surgical and pathologic findings in this case do not bear out the suggestion of Bársony and Schulhof[1] that the sclerotic changes in "ivory vertebra" may represent a reaction to a bacterial embolism with bacteria of low virulence setting up a local chronic infection.

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* Dr. Reed Harrow, Salt Lake City, furnished surgical and pathologic observation.

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THE RELATIONSHIP BETWEEN TUBERCULOSIS AND OSTEOCHONDRITIS VERTEBRAE (CALVÉ)

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THE definition of "osteochondritis vertebrae" is so confusing in the literature that anyone unfamiliar with this lesion must have difficulty in getting a clear idea of it. Even in up-to-date textbooks there are definitions which are more misleading than instructive, for instance only Kümmell's disease is described as osteochondritis vertebrae and Scheuermann's disease is written up as Calvé's disease. Various synonyms are reported collectively as spinal osteochondritis. A few typical examples may be mentioned: "Osteochondritis attacks the spine between the ages of fourteen and twenty years" (Kerley), or " . . . Calvé's epiphysitis is another member of this group of diseases, (osteochondritis juvenilis) and affects the epiphysis of a vertebra. It is commoner in boys than girls, and appears about puberty." (Bailey and Love.)

A short résumé of the early stage of development may give a clearer conception. Ossification of a vertebra appears in three primary centers and five secondary centers. The three primary centers are (1) body; (2) and (3) right and left vertebral arch (or neural arch).

These three primary centers are present at birth and unite between the ages of three and six. About the age of puberty the secondary centers begin to appear. It seems to be unnecessary to mention further details, as this paper is confined to a lesion of the primary centers. To avoid any erroneous ideas it is highly important to distinguish between two different aspects of osteochondritis vertebrae. (See table next column.)

As Calvé's disease is a distinctly rare type of osteochondritis this paper discusses only some peculiarities which became a more or less diagnostic problem while observing a case.

The question as to whether this lesion is a distinct inflammatory process is still under discussion. In order not to use the term "osteochondritis" (symbol for inflammation), several investigators use the term "Calvé's disease," or to compare this lesion to a similar one of the hip joint (coxa plana) the term "vertebra plana." Other names such as osteochondropathia or osteonecrosis have been proposed and used, but have no more value than to obscure the etiology of this lesion.

Many causes for osteochondritis have already been published without any definite one having found acknowledgment. Therefore only an enumeration without claiming completeness can be presented:

(1) Congenital disturbance in development
(2) Nutritional disturbance
(3) Lues
(4) Osteomalacic type of rickets
(5) Trauma
(6) Endocrine disturbance
(7) Interruption in development and trauma (taken separately ineffective, together effective)
(8) Disturbance in ossification
(9) Embolic blockage of terminal artery
(10) Hypoplasia or malformation
(11) Mild hematogenous infection.

It may be that I have not come upon other theories, which would have added to the completeness of the list. Its ramifications bring sufficient proof that it still requires much research work to clear up the etiology of osteochondritis. The theory

OSTEOCHONDRITIS VERTEBRAE

Primary Centers	Secondary Centers
1. Age: before 10 years	1. Age: about puberty
2. Vertebral bodies	2. Epiphyseal plates
3. Calvé's disease or vertebra plana	3. Scheuermann's disease or juvenile kyphosis

of a mild hematogenous infection has much in its favor. Calvé's disease is a localized affection of the spine with the clinical aspects of Pott's disease. Only one author (Fawcitt) reports vertebra plana associated with pathological changes in other bones. In this connection with the clinical aspect of tuberculosis we may mention recent publications which refer to the presence of tubercle bacilli in cases of Köhler's disease. Even more we find publications that Köhler's disease of the scaphoid is a hematogenous infection by tubercle bacilli of low virulence (Greenwood, Faulkner). Köhler himself, in contradistinction, is of the opinion that "the affection has nothing to do with tuberculosis (although TB. is not unknown in this bone) and to tuberculosis the typical roentgenogram bears no resemblance." Dale mentions in his paper that mild infectious agents, including tuberculosis, may in different cases be responsible for the characteristic roentgenographic appearance. On the other hand, he states that tuberculosis can be excluded by negative tuberculin reaction, in spite of tubercle bacilli being responsible in some cases. I personally doubt whether a negative tuberculin reaction is entirely correct in excluding the presence of tuberculosis. Mantoux's intradermal test for tuberculosis is an extremely delicate one and this fact restricts its clinical value (Price). Mantoux's test has been carried out in our case under observation and has been published in several others. A diagnosis which depends on a positive or negative Mantoux's test seems to rest on insecure foundations. I have observed several times that a negative Mantoux test has no justification in excluding tuberculosis. A positive reaction can be misleading, for instance in supposing that tuberculosis is the causative factor in bone lesions, if really the positive reaction is caused by a symptomless infection of the mesenteric glands. And what is the position in a negative reaction, if the infection is caused by the bovine type of tubercle bacillus? It is established that a small percentage of infected persons react only either to bovine or to human tuberculin. From all critical evidence it appears that a negative tuberculin reaction has no decisive significance in establishing whether a tuberculosis infection has occurred or not. Regeneration and escape of an intervertebral disc are signs of vertebra plana. It may be problematic whether this evidence should be brought as sufficient proof against mild tuberculous infection, because recovery and regeneration are not unknown in tuberculous foci of the bone. Further, against tuberculosis is argued the fact that in cases of vertebra plana only one vertebra is affected, while tuberculosis should occur in at least two vertebrae. Rummel's statistics (Langenbeck's Archiv, 1930, B. 160, S. 771) show that in 178 cases of spondylitis, 48 were affected by a tuberculous process in one vertebra, 82 in two vertebrae and in the remainder in several vertebrae. In children the maximum incidence for tuberculosis and Calvé's disease is between the ages of four and seven. In osteochondritis vertebrae (Calvé) only the vertebral body is affected similar to cases of Pott's disease, probably on account of an exceptionally rich blood supply. Since not one case of vertebra plana in the early stage has been published with pathological anatomical controls, it therefore appears unjustified in vertebra plana either to accept or to exclude as a causative factor an infection with tubercle bacilli. As far as we know, only one case of vertebra plana has been published with morbid anatomical confirmation. In this case Mezzari states that the lesion was in a stage of advanced regeneration and consequently it was difficult to ascertain the onset and etiology. He is of the opinion that his case was caused by hereditary lues. Unfortunately, extensive biochemical and laboratory examinations are not mentioned in the published cases which I have been able to check. It may be that in one or the other case these would have contributed to the clarifying of the debatable manifestation. In our observation, unfortunately only a sedimentation test (besides the Mantoux test) has been carried out, which

was markedly increased—20/50 Westergreen. Increased, and especially high, sedimentation rates are strongly in favor of the inflammatory nature of the disease. I am of the opinion that in vertebra plana the inflammatory theory is quite correct, in which the question must at present remain unsettled as to what causative factors are predominant. It has further to be noted that the possibility of numerous, small unnoticed traumata spread over months might act as a secondary, contributory cause.

The lower portion of the dorsal spine is predominantly affected. Only very few cases are reported with localization of the lesion in the lumbar spine. It appears that those vertebrae are mostly affected which are mechanically exposed to the greatest pressure. The lower dorsal region is exposed to the greatest stresses and strains. It is here, therefore, that the most striking changes occur.

Finally the roentgenological features may be closely interwoven: (1) only one vertebra involved; (2) the body collapsed, sometimes to a marked degree; (3) the body has increased density; (4) the intervertebral disc above and below the affected body remains intact with occasional widening of the intervertebral space; (5) partial regeneration.

Regeneration occurs very late; in the case published by von Hecker and Thews, not before the third year. It is obvious that recovery is directly connected with the exact time of the diagnosis. An early discovery of the lesion with consequent treatment is the best foundation for recovery, which cannot be expected in the same cases untreated or diagnosed too late. The late onset of the recovery seems also to point to a chronic inflammation, whose original cause has still to be cleared up, and which calls for a special investigation.

The differential diagnosis requires consideration of Pott's disease, which gives rise to more or less similar manifestations, if it is possible to exclude traumatic injury with certainty. As the apparent etiology of osteochondritis vertebrae (Calvé) has not been completely decided on, one can say only that both diseases are identical in the initial stage. Therefore, an early diagnosis of Pott's disease is customary, and this will later be doubted and then corrected, particularly on account of a negative tuberculin reaction. Whether right or wrong, this view would have to be confirmed by further research. The roentgen findings in the cases of Calvé's disease are most important as the clinical symptoms are insignificant. The roentgen findings alone, however, prove nothing, and one should not make any diagnosis from the roentgenological appearance alone. Evaluation of the history, clinical findings, laboratory reports and follow-up observations, all have to be considered together with the result of the roentgen examination, to lead to a diagnosis, which may have the best foundation in suspected cases of vertebra plana, until pathologic-anatomical observations have been reported.

The observations in the following case of suspected vertebra plana caused further investigation to be made on the criteria of the aspects of this disease from the diagnostic point of view.

CASE REPORT

The patient, a male, aged three and a half, was brought to the doctor suffering from sore back for about two weeks. Family and past history were irrelevant. There was no personal or family history of tuberculosis. No other history was elicited with reference to the back. A definite scoliosis was present on physical examination. Diagnosis:?Acute muscular spasm. Otherwise he was quite well. No laboratory examinations have been made previously and no other physical pathological findings are recorded. As no changes could be observed after several weeks, the boy was referred to me for roentgen examination of the spine. Tuberculin reaction (Mantoux test) carried out after the first roentgen examination was negative. Sedimentation rate 20/50 Westergreen.

Roentgen Examination. The body of the ninth dorsal vertebra shows collapse with irregular trabeculation and areas of increased density

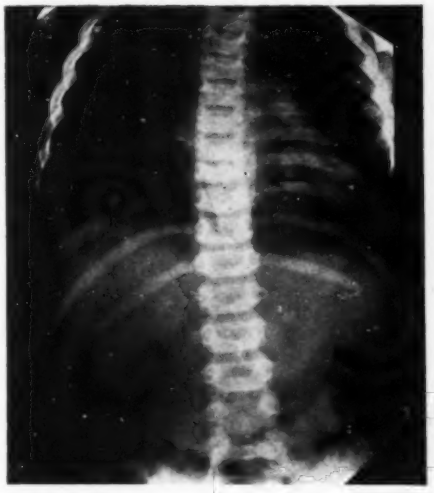

Fig. 1. This roentgenogram shows collapse of the ninth dorsal vertebra. The paravertebral shadow is clearly recognizable (arrows).

within the body. Intervertebral space almost unaffected. Fusiform shadow on a level with the ninth dorsal vertebra, suggesting paravertebral abscess. During eight months of observation the paravertebral shadow shows partial insignificant changes in its configuration. It was present upon both sides, particularly the left side (Fig. 1 and 2). Otherwise no marked changes could be observed on several control examinations in eight months. Repeated roentgen examinations of the chest were negative for tuberculosis or any other disease. Roentgenoscopy of the whole skeleton did not reveal any evidence of further bony lesion.

Comment. As the clinical examination did not suggest any definite or even tentative diagnosis, we had to depend entirely on the roentgen findings. The first roentgen examination gave no evidence for a definite diagnosis, fracture and tuberculosis having been considered. The first control examination gave rise to more suspicion of tuberculosis, because clinically there was no evidence of trauma and because the fusiform paravertebral shadow had to be considered as a possible abscess. The Mantoux test carried out after the first roentgen examination was negative; roentgen examination of the chest did not disclose any evidence of tuberculosis, which was confirmed by later control examinations. Therefore the clinician ruled out any possibility of tuberculosis. The differential diagnosis was later so evaluated that a diagnosis of vertebra plana could be accepted with a fair amount of probability. With the reading of the roentgenograms the question always arose as to how the paravertebral shadow could be explained or interpreted. These shadows are usually observed in trauma, and particularly in tuberculosis, and in those cases usually upon both sides. They are, however, not actually pathognomonic of tuberculosis, as they are also found in staphylococcus osteomyelitis, pneumococcus, typhoid and paratyphoid abscesses. The clinical signs and the roentgen appearance in these diseases are quite different from those of our observation. Brailsford states that in the acute phase of vertebra plana the involved body is surrounded by a fusiform expansion which within a few weeks gradually disappears. The disc remains intact, but the vertebral body is compressed. It is obvious that our findings are quite different in this respect, because the paravertebral shadow was still

Fig. 2. Roentgenogram showing collapse of the ninth dorsal vertebra in lateral projection. Intervertebral spaces above and below unaffected.

present after an observation of about eight months. This striking finding must lead to an investigation of the underlying pathology. As a biopsy study was not possible in our case and such a study has not yet been published, we were confined to a theoretical explanation, and so the discussion of the etiology will again be opened. Trauma may

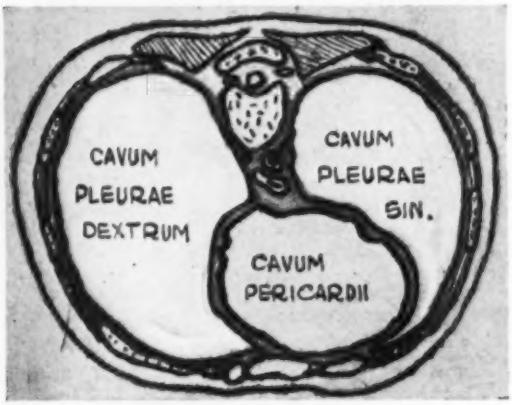

FIG. 3. Diagram showing arrangement of fascia endothoracica as seen in transverse section of the thorax.

cause a hemorrhage or effusion of blood; inflammation can be accompanied by serious lymphocytic exudation similar to epituberculosis. Clinically, there was no evidence of any traumatic injury and in such a case, absorption would have taken place during the long period of observation. Consequently only inflammation remained to be considered. The stereoscopic examination had shown that the paravertebral shadow was situated particularly in the front of the spinal lesion, partly extending to the left side and to a lesser degree to the right. The spine is enveloped by fairly strong ligaments. Each lesion which perforates from the vertebral body to the adjacent structures has to overcome this strong obstacle to reach the next tissue, the endothoracic fascia of the posterior mediastinum (Fig. 3). Here, in most of the cases, the lesion becomes localized. Presumably there are connections between fascia and ligaments of the dorsal spine, like the bulkheads which divide the different portions of the spine into segments. Otherwise it would be very difficult to explain why in certain lesions of the dorsal spine the paravertebral abscess is almost always localized and extends symmetrically on both sides. The density of the paravertebral shadow seems to be homogeneous, increased in density by summation on roentgenograms in anteroposterior projection, whereas a dimunition in density is obvious in the lateral views. It appears difficult to explain satisfactorily the cause of the paravertebral shadow. Probably we are dealing with a low grade chronic inflammation, which constantly maintains exudation and prevents absorption. The configuration of the shadow excludes a complete organization and secondary fibrosis, which could already have taken place. Very likely secondary changes of the mediastinal pleura are involved and play their part. When we consider a low grade infection of tuberculous origin, then, logically, comparisons with epituberculosis arise. In these cases exudation in the neighborhood of the original focus is observed, which is very slowly absorbed and can be followed for months on roentgen examination, until it finally disappears. Similar processes are not known to me in cases of nonspecific inflammation with similar clinical symptoms. The increased sedimentation rate points only to an inflammatory lesion whose etiology is still obscure.

My investigations are not able to prove conclusively that vertebra plana is caused by tubercle bacilli of low virulence. However, it seems to me that there are certain reasons to suspect the tubercle bacillus, as the cause of this lesion, which certainly are sufficiently valid for me to ask for a discussion on this matter.

SUMMARY

(1) Osteochondritis vertebrae (Calvé) is explained in its different aspects.

(2) The etiology is discussed.

(3) The question arises as to whether

tubercle bacilli of a low virulence are a causative factor.

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PSEUDONEOPLASM AS A POST-APPENDECTOMY FINDING

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ALTHOUGH benign solitary polyps of the colon are uncommon, it is essential that they be recognized. True polyps with few exceptions are adenomas, and therefore must be eradicated because of their marked tendency to undergo malignant degeneration. Since they may be found in any part of the colon, the study above the reach of the sigmoidoscope is dependent upon the roentgen examination. Several conditions which simulate polyps can be differentiated roentgenologically. Fecal masses

FIG. 1. Case 1. Spot roentgenogram of cecum showing large rounded polypoid lesion, arising from medial wall of the cecum.

may be indistinguishable from polyps in the course of a single examination, but repetition of the examination would indicate the true nature of the lesion as it would not be reduplicated. Golden has reported polypoid lesions, resulting from edema of the ileocecal valve. He also established a criterion for its diagnosis, viz., that the filling defect produced by this condition surrounds the intracolic portion of the ileum.

Though rarely reported, a relatively common condition which can simulate a polyp is the inverted stump of the appendix. In a consecutive series of 260 barium enema examinations performed within a period of eight months, filling defects were found in the cecum of 4 patients. Typically, it arose from the wall of the cecum below the ileocecal valve at the usual site of origin of the appendix. The presenting complaints and the physical findings in these cases were of a diverse nature and could not be correlated with a lesion of the cecum. The patients shared one feature in common in their past history: all of them had had previous appendectomies. In view of this past history, the location and nature of the lesion and the apparent innocence of the findings such that they could not be correlated with the clinical picture, the filling defects were interpreted as representing the invaginated stumps of appendices.

CASE REPORTS

CASE 1. Mrs. A. C. (Unit No. 38930), aged thirty-two, was first seen at this clinic in November, 1944, having vague pains in the region of the umbilicus with rectal urgency and no relief by evacuation. This pain was intermittent in character. A barium enema revealed a polypoid lesion in the cecum (Fig. 1) which was interpreted as probably representing an inverted appendiceal stump. Subsequently, the patient had a hysterectomy for fibroids. At surgery palpation of the cecum failed to reveal any evidence of a lesion within the cecum, nor was any lesion found involving the intestinal tract other than a few adhesions to the cecum and omentum. Because of the negative findings at the time of operation, the barium enema was repeated, using the double contrast method. This revealed the polypoid lesion below the ileocecal valve projecting into the lumen of the cecum. It measured approximately 12 mm. in diameter. This patient had had an appendectomy and oophorectomy twelve years previously.

Case II. C. A. (Unit No. 36777), male, aged twenty-nine, had an appendectomy in 1938. He first presented himself to this clinic June 13, 1945, with complaints of "heartburn," intolerance for condiments and greasy foods of four months' duration. The upper gastrointestinal study was normal. The patient had only partial relief from medical treatment, consisting of bland diet, antispasmodic and antiacid. A barium enema revealed a rounded polypoid lesion of approximately 1 cm. diameter in the medial portion of the cecum (Fig. 2) which was considered characteristic of an inverted appendiceal stump.

Case III. J. C. (Unit No. 52008), male, aged forty-three, had an appendectomy twenty-five

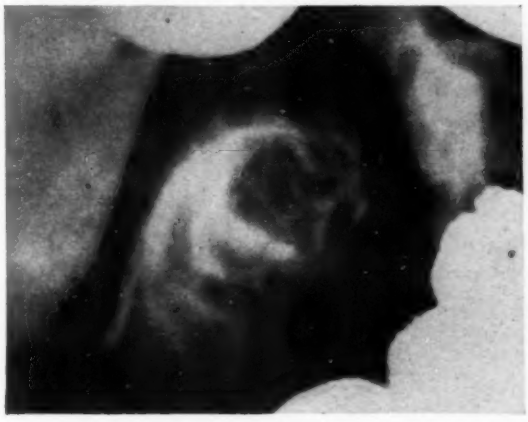

Fig. 2. Case II. Spot roentgenograms of cecum with compression revealing irregular polypoid lesion in the cecum below the ileocecal valve.

years ago. He presented himself to the clinic April 23, 1945, complaining of constipation of many years' duration and he had taken laxatives daily. The barium enema revealed the polypoid lesion located at the apex of the cecum which was funnel-shaped (Fig. 3). This was considered to represent the inverted stump of the appendix. A stereoscopic, double contrast study confirmed the presence of an intraluminal polypoid mass in the cecum.

Case IV. Mrs. S. Z. (Unit No. 32947), aged thirty-one, presented herself to the clinic for the first time on March 31, 1943, with complaint of pain in the right upper quadrant which radiated to the back. The pain was of a constant character. She had a fat intolerance. Cholecystogram

Fig. 3. Case III. Small spot roentgenogram of cecum showing small rounded polypoid lesion at apex of a funnel-shaped cecum.

confirmed the clinical impression of biliary calculi. The patient was under medical treatment, but this proved to be unsuccessful and a cholecystectomy was performed on August 7, 1945. The surgeon examined the viscera and noted no abnormality in the cecum. The preoperative barium enema had revealed a small fill-

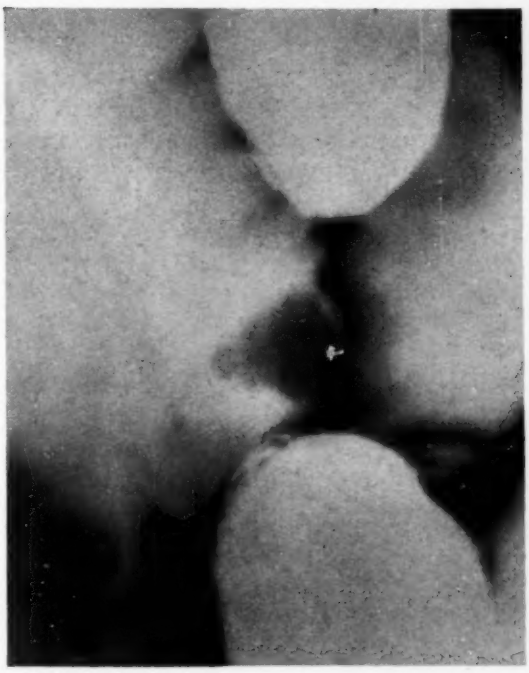

Fig. 4. Case IV. Spot roentgenogram of cecum showing triangular-shaped polypoid lesion, arising from medial wall of the cecum.

FIG. 5. First postmortem specimen. The specimen fills with barium.

ing defect near the apex of the cecum which was believed to be due to the inverted appendiceal stump (Fig. 4).

As definite proof was not offered by these cases, a study of the postmortem specimen of the cecum of a patient who died of an unrelated cause (rupture of an aneurysm of the

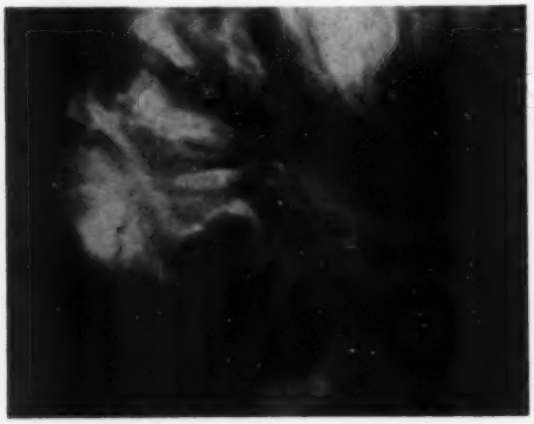

FIG. 6. First postmortem specimen. The barium has been partially expressed to show the mucosal pattern and the nature of the filling defect in the cecum. In this case, the base of the polypoid lesion was quite broad.

FIG. 7. First postmortem specimen photograph showing the polypoid, umbilicated inverted appendiceal stump below the ileocecal valve.

circle of Willis) was performed. This patient had had an appendectomy more than a year previously. The specimen was examined roentgenoscopically with the lumen filled with barium (Fig. 5 and 6). This revealed a lesion similar in character and location to that found in the first, second and fourth cases. Upon opening the specimen, a polypoid lesion with a narrow but deep umbilication at its free surface was found (Fig. 7). It proved to be an inverted stump which upon microscopic exami-

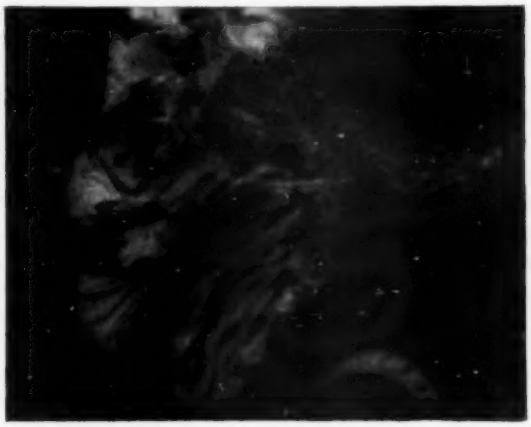

FIG. 8. Second postmortem specimen with the barium expressed.

nation was shown to contain a small abscess.

Two other postmortem specimens were examined. In these instances, the appendices were intact. The lumina of the cecums were filled with barium. No evidence of any filling defects or other abnormality could be found (Fig. 8). The barium was then evacuated and appendectomies were performed in the usual manner.

Fig. 9. Same specimen after appendectomy and inversion of the appendiceal stump.

Re-examinations with barium revealed (Fig. 9 and 10) typical polypoid lesions arising from the points of origin of the appendices.

Artner[1] in 1929 described "ring shadows" in cecums which were demonstrated in the article as concentric annular shadows with a central filling defect. He was able to duplicate these findings with barium studies of postmortem specimens and proved them to be due to inverted stumps of appendices. Patients were examined eight to ten days postoperatively, several months postoperatively, and several years postoperatively. No significant variation in the frequency of the findings was noted in the three groups. In all of these cases, there were no complaints which could be correlated with this finding. He was able to define this "ring" shadow in one-third of the patients who had had appendectomies regardless of the lapse of time since surgery.

Fig. 10. Third postmortem specimen following appendectomy and inversion of the appendiceal stump.

Weber and Good[7] report 4 instances in which lesions observed roentgenologically proved to represent invaginated appendiceal stumps upon surgical investigation. These patients had had appendectomies as long as eighteen years previous to the report. Similar lesions were observed in 4 additional cases which were not operated upon because it was believed that they too represented inverted appendiceal stumps.

The inverted stump of the appendix is generally considered to be innocuous except for the possibility that it may harbor an abscess, as in the instance of the first specimen described above. Sequelae of this, though rare, are accepted as potential dangers of the early postoperative period[3, 4] yet Schrager[5] was able to report a case in which a stump abscess lay dormant two years and then perforated into the general peritoneal

cavity with resultant peritonitis. Artner speculates that inversion might cause local irritation for he found that there was an abnormal cecal stasis of barium in patients with inverted appendiceal stumps. Weber and Good postulate that the inverted stump might give rise to an intussusception.

SUMMARY

Attention is again called to the fact that inverted appendiceal stump can simulate true polyps; they were demonstrated in four patients and in a postmortem specimen. In addition, the finding was reproduced by performing appendectomies in two additional postmortem specimens. It is important that these be correctly evaluated for true adenomas must be eradicated because of their marked tendency to undergo malignant degeneration.

Northern Permanente Foundation
Vancouver, Wash.

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THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

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Committee on Arrangements: To be appointed.

Twenty-ninth Annual Meeting: Seaside Hotel, Atlantic City, N. J., June 9–10, 1947.

EDITORIALS

THE CIRCULATORY EFFECTS OF OSTEITIS DEFORMANS (PAGET'S DISEASE)

OSTEITIS deformans or Paget's disease is one of the most frequently encountered bone dyscrasias in the roentgen department. Czerny[1] in 1873 first used the term "osteitis deformans" to describe softening and deformity of the tibia and fibula in a young soldier. Sir James Paget,[2] unaware of this, later, in 1877, published his classical description of a disease for which he suggested the term osteitis deformans because of his belief in the inflammatory nature of the lesion, but following his description the disease is known generally by his name.

The highly vascular state of the bones affected has long been recognized both by orthopedic and cranial surgeons and this feature of the bone change has been emphasized. It was also noted by Klippel and Weil[3] that the temperature of the skin over an affected bone was higher than normal. The cardiovascular complications of the generalized form of Paget's disease has also been generally recognized.

Kay, Simpson and Riddoch[4] began their original investigation of osteitis deformans to ascertain the frequency of neurological changes in this disease but the study was expanded into a more comprehensive clinical and biochemical investigation.

These investigators were impressed by the frequency of high pulse pressures in the series of cases which they studied. They observed that in a large group of cases the pulse pressures were over 60 mm. of mercury and that cardiac enlargement was often noted, as were systolic murmurs over the precordium. This in spite of the fact that there was no satisfactory evidence of aortic valvular disease.

Kay and his collaborators, as well as Snapper,[5] ascribed these findings to arteriosclerosis which is so frequently associated with Paget's disease.

An editorial in the *Lancet*[6] has recently called attention to further light that has been thrown on these phenomena by a detailed study of a case in the British Postgraduate Medical School. "A patient with generalised Paget's disease had venous congestion and oedema. Cardiac catheterisation showed that his cardiac output was 13.3 litres per minute, or nearly three times the normal average." This observation is somewhat similar to that found in arteriovenous aneurysms and it was found that closing the circulation through the legs of the patient under observation produced effects on the general circulation similar to those seen when an arteriovenous aneurysm is partially shut off, including slowing of the pulse and the slight rise in diastolic arterial pressure.

This observation led the investigators to believe that the circulatory phenomena might be explained by a great increase in blood flow through the affected bones and they made a direct study of the bone blood flow. It was shown that when one tibia only is affected by Paget's disease the flow through that leg may be five to seven times as high as that in the normal leg. By plethysmographic study the actual bone blood flow was estimated in the humerus of a normal person and in the patient with

[1] Czerny, V. *Wien. med. Wchnschr.*, 1873, *23*, 896. Quoted by Kay, Simpson and Riddoch.[4]

[2] Paget, J. *Tr. Roy. Med.-Chir. Soc.*, 1877, *60*, 37. Quoted by Kay, Simpson and Riddoch;[4] also, *Med. Classics*, 1936, *1*, 29–54.

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[5] Snapper, I. Medical Classics on Bone Disease, New York, 1943. Quoted by *Lancet*.[6]

[6] Editorial. Circulatory effects of osteitis deformans. *Lancet*, 1946, *2*, 568.

Paget's disease. From these studies it was found that the normal flow was probably about 1 cc. per 100 cc. of bone per minute, while that through Paget's bones was about 20 cc. "Applying these figures to the whole skeleton, the total skeletal blood-flow is normally about 75 c. cm. per minute, while the enlarged skeleton of the case of generalised Paget's disease received a blood-flow of about 3.3 litres per minute."

These observations are of extreme importance. It is an important contribution to the living pathology of Paget's disease and it also is the first time that bone blood flow has been measured in man. As the *Lancet* quite properly comments, "It adds another thought-provoking instance to the group of conditions in which 'cardiac failure' is associated with high output, of which severe anaemia constitutes a well-established example."

A complete understanding of the nature and sequence of events in these cases of apparent heart failure will no doubt shed much light on other ordinary forms of heart failure and as a result of the observations of these investigators much additional information may be gained from research in this particular field. The possibility of the utilization of radioactive isotopes may play an important part in the elucidation of some of these hitherto obscure conditions associated with cardiac failure.

ROENTGENOLOGIC KYMOGRAPHIC STUDIES OF THE HEART IN THE PRESENCE OF AN ARTERIOVENOUS FISTULA

ROENTGENOLOGIC kymographic studies of the heart and great vessels are used routinely in many radiological departments in the study of the pathologic states of the heart and great vessels, and roentgen kymography is also of considerable aid in a differential diagnosis between mediastinal tumors and enlargements or aneurysms of the thoracic aorta.

Quite recently Holman[1] employed roentgen kymography of the heart in the presence of an arteriovenous fistula with his interpretation of these studies.

Arteriovenous fistulae and their effects upon the heart and circulation have for a number of years been the subject of numerous clinical observations and, as Holman quite properly says, much philosophical discussion and extensive experimentation. Many of the observations have seemed at times contradictory and their explanation elusive. Holman also adds that more often than not observations have been recorded without attempts at explanation.

Holman had the opportunity recently of observing two cases of arteriovenous fistula in which cardiac and aortic silhouettes were obtained by roentgen kymography. As a result of the kymographic studies significant changes in the cardiac and aortic silhouettes occurred which provided important information regarding the sequence of events which occur in the circulatory apparatus on closing or opening a fistula. In addition instructive evidence was obtained applicable to the explanation of the almost mysterious retardation in pulse rate that accompanies closure of a large fistula.

Holman's roentgen kymographic studies provided important observations on the effect upon the heart and large vessels of closing of a large arteriovenous fistula. The immediate effect he observed was shown to be additional distention of an already dilated heart and aorta. "This distention is due to backing up into the arterial bed the volume of blood formerly flowing through the fistula into the capacious venous bed. Since a large fistula of long duration is invariably accompanied by an increased total blood volume the entire arterial bed including the left heart and aorta is overdistended by this increased blood volume when the leak into the venous bed is suddenly closed. The immediate effect of such an overdistention of the arterial tree is a marked elevation of general blood pressure, which is promptly though not completely rectified by a slowing of the cardiac contractions and by a retardation in pulse rate which is unique. Its mechanism is dependent upon stimulation of the fibers of the depressor nerve in the arch of the aorta by the overdistention of this vessel on closure of the fistula. . . . It is dependent entirely upon the increase in total blood volume that occurs in the presence of a fistula of large size and long duration. If the closure of the fistula is permanent, . . . blood pressure and pulse return to normal through gradual reduction of blood volume to normal."

Holman was able by his roentgen kymographic studies to prove unequivocally that there does occur enlargement of the aorta on closing a fistula and that the roentgen kymogram is highly important evidence in the explanation of the slowing of the pulse which is invariable in the presence of a fistula large enough and of sufficient duration to produce a significant and demonstrable increase in total blood volume.

It has been known for some time that there is a distention of the regional arteries on the closing of a fistula and Holman now by the roentgen kymographic studies has revealed a definite enlargement of the aorta on closing a fistula. This abnormal disten-

[1] Holman, E. Roentgenologic kymographic studies of the heart in the presence of an arteriovenous fistula and their interpretation. *Ann. Surg.*, 1946, *124*, 920–933.

tion of the arch of the aorta in which reside the end-organs of the depressor nerve results in stimulation of these efferent vagal fibers, and an immediate slowing of the cardiac contraction rate occurs to neutralize or compensate for the excessive high blood pressure incident to overdistention of the arterial bed.

Holman concludes from his studies that there can be no question of this intimate relationship of the retardation in pulse rate and of the increased blood pressure to the increase in total blood volume, which varies greatly depending on the variations in quantity of blood diverted through the fistula which, in turn, is determined by the variables already described. By his roentgen kymographic studies he obtained additional evidence supporting the importance of the increased blood volume in the behavior of blood pressure following permanent elimination of a fistula. The increase in systolic pressure following closure of a fistula soon subsides to normal as the increased blood volume is corrected. Concomitantly the retarded pulse rate again returns to normal.

It is of extreme interest that by use of roentgen kymographic studies of the heart in the presence of an arteriovenous fistula many of the points of controversy in arteriovenous fistula and their effects upon the heart and circulation have been elucidated.

With the marked increase of arteriovenous fistulae that has occurred as a result of the war, much profitable information may be gained by a utilization of roentgen kymography in the preoperative and postoperative study of these cases.

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this section solicited promptly after the events to which they refer

MEETINGS OF THE ROENTGEN SOCIETIES*

UNITED STATES OF AMERICA

AMERICAN ROENTGEN RAY SOCIETY
Secretary, Dr. H. Dabney Kerr, University Hospital, Iowa City, Iowa. Annual meeting: Haddon Hall, Atlantic City, N. J., Sept. 16–19, 1947.

AMERICAN RADIUM SOCIETY
Secretary, Dr. H. F. Hare, 605 Commonwealth Ave., Boston, Mass. Annual meeting: Seaside Hotel, Atlantic City, N. J., June 9–10, 1947.

RADIOLOGICAL SOCIETY OF NORTH AMERICA
Secretary, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N. Y. Annual meeting: Hotel Statler, Boston, Mass., Nov. 30–Dec. 5, 1947.

AMERICAN COLLEGE OF RADIOLOGY
Secretary, Mac F. Cahal, 20 N. Wacker Drive, Chicago 6. Annual meeting: Haddon Hall, Atlantic City, N. J., June 8, 1947.

SECTION ON RADIOLOGY, AMERICAN MEDICAL ASSOCIATION
Secretary, Dr. U. V. Portmann, Cleveland Clinic, Cleveland, Ohio. Annual meeting: Atlantic City, N. J., June 9–13, 1947.

ALABAMA RADIOLOGICAL SOCIETY
Secretary, Dr. John D. Peake, Mobile Infirmary, Mobile Ala. Next meeting time and place of Alabama State Medical Association.

ARKANSAS RADIOLOGICAL SOCIETY
Secretary, Dr. Fred Hames, 511 National Bldg., Pine Bluff, Ark. Meets every three months and also at time and place of State Medical Association.

BROOKLYN ROENTGEN RAY SOCIETY
Secretary, Dr. A. H. Levy, 1354 Carroll St., Brooklyn 13, N. Y. Meets monthly on fourth Tuesday, October to April.

BUFFALO RADIOLOGICAL SOCIETY
Secretary, Dr. Joseph S. Gian-Francheschi, 610 Niagara St., Buffalo, N. Y. Meets second Monday of each month except during summer months.

CENTRAL NEW YORK ROENTGEN RAY SOCIETY
Secretary, Dr. C. F. Potter, 820 S. Crouse Ave., Syracuse. Three meetings a year. January, May, November.

CHICAGO ROENTGEN SOCIETY
Secretary, Dr. T. J. Wachowski, 310 Ellis Ave., Wheaton, Ill. Meets second Thursday of each month October to April inclusive at the Palmer House.

CINCINNATI RADIOLOGICAL SOCIETY
Secretary, Dr. Samuel Brown, 707 Race St., Cincinnati, Ohio. Meets third Tuesday of each month, October to May, inclusive.

CLEVELAND RADIOLOGICAL SOCIETY
Secretary, Dr. George L. Sackett, 10515 Carnegie Ave. Cleveland 6, Ohio. Meetings at 6:30 P.M. on fourth Monday of each month from October to April.

DALLAS-FORT WORTH ROENTGEN STUDY CLUB
Secretary, Dr. X. R. Hyde, Medical Arts Bldg., Fort Worth, Texas. Meets in Dallas on odd months and in Fort Worth on even months, on third Monday, 7:30 P.M.

DENVER RADIOLOGICAL CLUB
Secretary, Dr. W. C. Huyler, 1619 Milwaukee, Denver 6, Colo. Meets third Friday of each month at Department of Radiology, Colorado School of Medicine.

DETROIT ROENTGEN RAY AND RADIUM SOCIETY
Secretary, Dr. E. R. Witwer, Harper Hospital. Meets monthly on first Thursday from October to May, at Wayne County Medical Society Building.

FLORIDA RADIOLOGICAL SOCIETY
Secretary, Dr. J. M. Dell, Jr., 333 W. Main St., S., Gainesville, Fla. Meetings in May and November.

GEORGIA RADIOLOGICAL SOCIETY
Secretary, Dr. Robert Drane, DeRenne Apartments, Savannah, Ga. Meets in mid-winter and at annual meeting of Medical Association of Georgia in the spring.

RADIOLOGICAL SOCIETY OF KANSAS CITY
Secretary, Dr. Arthur B. Smith, 800 Argyle Bldg., Kansas City, Mo. Meets third Thursday of each month.

ILLINOIS RADIOLOGICAL SOCIETY
Secretary, Dr. Wm. DeHollander, St. John's Hospital, Springfield, Ill. Meets three times a year.

INDIANA ROENTGEN SOCIETY
Secretary, Dr. J. A. Campbell, Indiana University Hospitals, Indianapolis 7. Meets second Sunday in May.

IOWA X-RAY CLUB
Secretary, Dr. Arthur W. Erskine, 326 Higley Bldg., Cedar Rapids, Iowa. Luncheon and business meeting during annual session of Iowa State Medical Society. Special meetings by announcement.

KENTUCKY RADIOLOGICAL SOCIETY
Secretary, Dr. W. C. Martin, 321 W. Broadway, Louisville. Meets annually in Louisville on first Saturday in Apr.

LONG ISLAND RADIOLOGICAL SOCIETY
Secretary, Dr. Marcus Wiener, 1430-48th St., Brooklyn, N. Y. Meets Kings County Med. Soc. Bldg. monthly on fourth Thursday, October to May, 8:30 P.M.

LOUISIANA RADIOLOGICAL SOCIETY
Secretary, Dr. J. R. Anderson, 1130 Louisiana Ave., Shreveport. Meets annually during Louisiana State Medical Society Meeting.

LOUISVILLE RADIOLOGICAL SOCIETY
Secretary, Dr. E. L. Pirkey, Louisville General Hospital, Louisville 2, Ky. Meets monthly on second Friday at Louisville General Hospital.

MICHIGAN ASSOCIATION OF ROENTGENOLOGISTS
Secretary, Dr. E. M. Shebesta, 1429 David Whitney Bldg., Detroit. Three meetings a year, Fall, Winter, Spring.

MILWAUKEE ROENTGEN RAY SOCIETY
Secretary, Dr. C. A. H. Fortier, 231 W. Wisconsin Ave., Milwaukee, Wis. Meets monthly on second Monday at University Club.

MINNESOTA RADIOLOGICAL SOCIETY
Secretary, Dr. Chauncey N. Borman, 802 Medical Arts Bldg., Minneapolis 2, Minn. Two meetings yearly, one at time of Minnesota State Medical Association the other in the fall.

* Secretaries of societies not here listed are requested to send the necessary information to the Editor.

Nebraska Radiological Society
Secretary, Dr. O. A. Neely, 924 Sharp Bldg., Lindoln, Neb. Meets third Wednesday of each month, at 6 P.M. at either Omaha or Lincoln.

New England Roentgen Ray Society
Secretary, Dr. George Levene, Massachusetts Memorial Hospitals, Boston, Mass. Meets monthly on third Friday, Boston Medical Library.

New Hampshire Roentgen Ray Society
Secretary, Dr. A. C. Johnston, Elliott Community Hospital, Keene, N. H. Meets four to six times yearly.

New York Roentgen Society
Secretary, Dr. Ramsay Spillman, 115 East 61st St., New York City. Meets monthly on third Monday, New York Academy of Medicine, at 8:30 P.M.

North Carolina Radiological Society
Secretary, Dr. J. E. Hemphill, 323 Professional Bldg., Charlotte 2, N. C. Meets in May and October.

North Dakota Radiological Society
Secretary, Dr. L. A. Nash, St. John's Hospital, Fargo. Meetings held by announcement.

Ohio Radiological Society
Secretary, Dr. Henry Snow, 1061 Reibold Bldg., Dayton, Ohio. Meets during annual meeting of Ohio State Medical Association.

Oklahoma State Radiological Society
Secretary, Dr. P. E. Russo, 230 Osler Bldg., Oklahoma City, Okla. Three regular meetings annually.

Orleans Parish Radiological Society
Secretary, Dr. Joseph V. Schlosser, Charity Hospital, New Orleans 13, La. Meets first Tuesday of each month.

Pacific Roentgen Society
Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif. Meets annually, during meeting of California Medical Association.

Pennsylvania Radiological Society
Secretary, Dr. J. M. Converse, 416 Pine St., Williamsport.

Philadelphia Roentgen Ray Society
Secretary, Dr. C. L. Stewart, Jefferson Hospital. Meets first Thursday of each month, October to May, at 8:00 P.M., in Thomson Hall, College of Physicians.

Pittsburgh Roentgen Society
Secretary, Dr. L. M. J. Freedman, 115 South Highland Ave. Meets 6:30 P.M. at Webster Hall Hotel on second Wednesday each month, October to May inclusive.

Portland Roentgen Club
Secretary, Dr. Selma Hyman, University of Oregon Medical School, Portland, Oregon. Meets monthly 2d Wednesday, 8:00 P.M., Library of University of Oregon Medical School.

Radiological Section, Baltimore Medical Society
Secretary, Dr. Walter L. Kilby, Baltimore. Meets third Tuesday each month, September to May.

Radiological Section, Connecticut Medical Society
Secretary, Dr. Robert M. Lowman, Grace-New Haven Community Hospital, New Haven 11, Conn. Meets bimonthly on second Thursday, at place selected by Secretary.

Radiological Section, Los Angeles Co. Med. Assn.
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Radiological Section, Southern Medical Association
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Radiological Society of New Jersey
Secretary, Dr. W. H. Seward, Orange Memorial Hospital, Orange, N. J. Meets annually at time and place of State Medical Society. Mid-year meetings at place chosen by president.

Rochester Roentgen Ray Society, Rochester, N. Y.
Secretary, Dr. Murray P. George, Strong Memorial Hospital. Meets monthly on third Monday from October to May, inclusive, 8 P.M. at Strong Memorial Hospital.

Rocky Mountain Radiological Society
Secretary Dr. A. M. Popma, 220 N. First St., Boise, Idaho. Mid-Summer Conference, Shirley Savoy Hotel, Denver, Colo., Aug. 7, 8, 9, 1947.

St. Louis Society of Radiologists
Secretary, Dr. Edwin C. Ernst, Beaumont Medical Building, St. Louis, Mo. Meets fourth Wednesday of each month, except June, July, August, and September.

San Diego Roentgen Society
Secretary, Dr. R. F. Niehaus, 1831 Fourth Ave., San Diego, Calif. Meets monthly, first Wednesday at dinner.

Section on Radiology, California Medical Association
Secretary, Dr. D. R. MacColl, 2007 Wilshire Blvd., Los Angeles 5, Calif.

Section On Radiology, Illinois State Medical Society
Secretary, Dr. H. W. Ackemann, 321 W. State St., Rockford, Ill.

Shreveport Radiological Club
Secretary, Dr. R. W. Cooper, Charity Hospital, Shreveport, La. Meets monthly on third Wednesday, at 7:30 P.M., September to May inclusive.

South Carolina X-Ray Society
Secretary, Dr. T. A. Pitts, Baptist Hospital, Columbia, S. C. Meets in Charleston on first Thursday in November, also at the time and place of South Carolina State Medical Association.

Tennessee Radiological Society
Secretary, Dr. J. M. Frère, 707 Walnut St., Chattanooga, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

Texas Radiological Society
Secretary, Dr. R. P. O'Bannon, 650 Fifth Ave., Fort Worth 4, Texas.

University of Michigan Department of Roentgenology Staff Meeting
Meets each Monday evening from September to June, at 7 P.M. at University Hospital.

University of Wisconsin Radiological Conference
Secretary, Dr. E. A. Pohle, 1300 University Ave., Madison, Wis. Meets first and third Thursdays 4:00 to 5:00 P.M., September to May inclusive. Room 203, Service Memorial Institute, 426 N. Charter St., Madison.

Utah Radiological Conference
Secretary, Dr. Henry H. Lerner, School of Medicine, University of Utah, Salt Lake City 1. Meets 1st and 3rd Thursdays monthly from 7:30 to 10 P.M., Salt Lake County General Hospital, September to June.

Utah State Radiological Society
Secretary, Dr. M. Lowry Allen, Judge Bldg., Salt Lake City 1, Utah. Meets third Wednesday in September, November, January, March and May.

Virginia Radiological Society
Secretary, Dr. E. L. Flanagan, 116 E. Franklin St. Richmond, Va. Meets annually in October.

Washington State Radiological Society
Secretary, Dr. Thomas Carlile, 1115 Terry St., Seattle. Meets fourth Monday each month, October through May, College Club, Seattle.

X-Ray Study Club of San Francisco
Secretary, Dr. Ivan J. Miller, 2000 Van Ness Ave. Meets monthly on third Thursday at 7:45 P.M., first six months of year at Lane Hall, Stanford University

Hospital, and second six months at Toland Hall, University of California Hospital.

Cuba

Sociedad de Radiología y Fisioterapia de Cuba
President, Dr. J. Manuel Viamonte, Hospital Mercedes, Habana, Cuba. Meets monthly in Habana.

Mexico

Sociedad Mexicana de Radiologia y Fisioterapia
General Secretary, Dr. D. P. Cossio, Marsella No. 11, Mexico, D. F. Meets first Monday of each month.

British Empire

British Institute of Radiology Incorporated with the Roentgen Society
Medical Members' meeting held monthly on third Friday at 2:30 p.m. and Ordinary Meeting at same time on following Saturday, October to May, 32 Welbeck St., London, W.1.

Faculty of Radiologists
Secretary, Dr. M. H. Jupe, 23 Welbeck St., London, W.1 England.

Section of Radiology of the Royal Society of Medicine (Confined to Medical Members)
Meets third Friday each month at 4:45 p.m. at the Royal Society of Medicine, 1 Wimpole St., London.

Canadian Association of Radiologists
Honorary Secretary, Dr. E. M. Crawford, 2100 Marlowe Ave., Montreal 28, Que. Meetings January and June.

Section of Radiology, Canadian Medical Association
Secretary, Dr. C. M. Jones, Inglis St., Ext. Halifax, N. S.

Société Canadienne-Francaise d'Electrologie et de Radiologie Médicales
Secretary, Dr. Origéne Dufresne, 4120 Ontario St., East, Montreal, P. Q.

Radiological Section of the Victorian Branch of the British Medical Association
Secretary, Dr. Keith Hallam, St. George's Hospital. K.E.W., Melbourne, E. 4, Victoria, Australia. Meets monthly from March to November inclusive.

Section of Radiology and Medical Electricity, Australasian Medical Congress
Secretary, Dr. H. M. Cutler, 139 Macquarie St., Sydney, New South Wales.

Radiological Section, New Zealand British Medical Association
Secretary, Dr. Colin Anderson, Invercargill, New Zealand. Meets annually.

South America

Sociedad Argentina de Radiologia
Secretary, Dr. Guido Gotta, Buenos Aires, Argentina. Meetings are held monthly.

Sociedad Peruana de Radiologia
Secretary, Dr. Julio Bedoya Paredes, Apartado, 2306 Lima, Peru. Meetings held monthly except during January, February and March, at the Asociación Médica Peruana "Daniel A. Carrión," Villalta, 218, Lima.

Continental Europe

Société Belge de Radiologie
General Secretary, Dr. S. Masy, 111 Avenue des Alliés, Louvain, Belgium. Meets monthly, second Sunday at Maison des Médecins, Brussels.

Ceskoslovenská společnost pro röntgenologii a radiologii v Praze
Secretary, MUDr. Roman Blána, Praha XII, Korunní 160, Czechoslovakia.

Polish Society of Radiology
First post-war inaugural meeting will be held in Warsaw, May 22 and 23, 1947.

Warsaw Section, Polish Society of Radiology
Secretary, Dr. L. Zgliczynski, Nowogrodzka 59, Warsaw, Poland. Meets monthly.

Societatea Romana de Radiologie si Electrologie
Secretary, Dr. Oscar Meller, Str. Banual Mărăcine, 30, S. I., Bucuresti, Roumania. Meets second Monday in every month with the exception of July and August.

All-Russian Roentgen Ray Association, Leningrad: USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson. Meets annually.

Leningrad Roentgen Ray Society
Secretaries, Drs. S. G. Simonson and G. A. Gusterin. Meets monthly, first Monday at 8 o'clock, State Institute of Roentgenology and Radiology, Leningrad.

Moscow Roentgen Ray Society
Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky. Meets monthly, first Monday, 8 p.m.

Scandinavian Roentgen Societies
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association.

Sociedad Espanola de Radiologia y Electrologia
Secretary, Dr. J. Martin-Crespo, Fuencarral, 7. Madrid, Spain. Meets monthly in Madrid.

Société Suisse de Radiologie (Schweizerische Röntgen-Gesellschaft)
Secretary for French language, Dr. Babaiantz, Geneva.
Secretary for German language, Dr. Max Hopf, Effingerstrasse 49, Bern. Meets annually in different cities.

RADIOACTIVE ISOTOPE CONFERENCE AT VANDERBILT UNIVERSITY, NASHVILLE, TENNESSEE

A full week's conference, beginning April 21 and extending through April 25, 1947, was given at Vanderbilt University, Nashville, Tennessee, for the purpose of acquainting physicians with the present state of knowledge, availability and practical use of radioactive isotopes for medical purposes.

A very complete course of lectures was given which, together with clinical and laboratory demonstrations, filled each of the five days and three evenings of the week. The program was arranged and conducted by members of the faculty of the Vanderbilt College of Medicine in cooperation with the Clinton Laboratories of the Monsanto Chemical Company and Oak Ridge Institute of Nuclear Studies.

It is obviously not possible to mention all of the individuals from these institutions who contributed to the program, but to those in attendance, the work of Drs. P. F. Hahn and C. W. Sheppard, and of Dr. G. R. Meneely, who conducted clinical demonstrations, appeared outstanding. The well organized and well conducted program itself attested to the excellent effort of many others of the Vanderbilt faculty.

The speakers were well chosen, each being an outstanding contributor in the field that he presented, and included such well known authorities as Dr. J. G. Gibson, 2nd, of Harvard Medical School and Peter Bent Brigham Hospital, Dr. Wm. F. Bale of the University of Rochester and Dr. Russell L. Haden of the Cleveland Clinic, together with outstanding men in the world of nuclear physics, such as Dr. P. C. Aebersold and Dr. L. W. Nordheim, Dr. W. C. Peacock and a number of their associates.

Each paper was chosen either to explain some fundamental point which physicians will need to know in order to make practical use of radioactive isotopes, or to present clearly some field in which this new and powerful tool can be applied to modern medicine. The explanatory papers were largely necessitated by the fact that this information, having been restricted for the last few years, has not been available. Each paper was presented clearly in simple language and in sufficient detail so that its content could be applied to the real problems of medicine and of research.

Two of the best features of the program were the presentation by the Vanderbilt group of their work with colloidal substances, particularly colloidal radioactive gold, in the treatment of diseases of the reticulo-endothelial system and the presentation by Dr. Gibson and his group, including Dr. J. F. Ross, of the use of radioactive iron in studies of shock, blood volume and the life cycle of the red blood cell. The former, in addition to being a scientific presentation including a considerable amount of new work, was a well chosen example of the therapeutic possibilities which exist now and in the future, while the latter was a typical example of the use of these substances in applied research.

Several papers, particularly the one by Dr. Alexander Hollaender on production of chromosome injuries by radioactive isotopes, illustrated the use of this tool in fundamental research.

Registrants came to the meeting from as far away as Texas and the Atlantic seaboard. It was noticeable, however, that, although physicians and institutions throughout the South had been circularized and invited to this meeting, very few radiologists attended, although some of the outstanding ones were present. This may, in part, account for the fact that the only subjects not well covered in this otherwise excellent program were the subjects of protection and tissue dosage, particularly the relationship between the time-rate factors which, while well known to radiologists, are not generally well known or understood by others.

It is a remarkable fact that radiologists have not yet taken the interest that might have been expected of them in this new radiological agent, which has already proved to be of great diagnostic and some

therapeutic value. If this situation continues, we may reasonably expect a recurrence of some of the disasters which marred the early use of radium and roentgen rays, particularly radium.

At the same time, speakers on this program, particularly those from Clinton Laboratories, showed that both knowledge and instrumentation for adequate control and protection are ready at hand and need only to be applied by those with clinical experience.

One obvious reason why better work has not been done in setting up standards for radiation measurements and safety procedures in radiology is the fact that most of the men who should have been doing this work have been engaged in war activity and are even yet in a somewhat disorganized state. There may be reason to doubt the wisdom of the major roentgen-ray and radium societies in abandoning their committees on standardization and protection in the face of this rapidly advancing new beneficence and new menace, although the new organization under the American College of Radiology may prove more efficient. It is certain that radiologists and physicists associated with them must take greater cognizance of this subject in the immediate future.

Vanderbilt University and the institutions associated with it in this effort are to be congratulated upon their timely and excellent presentation and their example should probably be followed in other parts of the country.

K. E. Corrigan

GEORGIA RADIOLOGICAL SOCIETY

The Georgia Radiological Society held its spring meeting at Augusta, Georgia, in conjunction with the annual meeting of the Medical Association of Georgia. On April 24 Dr. C. Allen Good, Jr., of the Mayo Clinic, Rochester, Minnesota, addressed the Association on the subject of "Roentgenologic Diagnosis of Tumors of the Small Intestine." This was followed by papers from the members of the Georgia Radiological Society as follows:

Dr. L. P. Holmes, Dr. Stephen W. Brown, and Dr. David Robinson, Augusta, Georgia, "The Incidence of Bone Tumors in a Large General Hospital."

Dr. James J. Clark, Atlanta, Georgia, "Roentgenological Survey of the Genitourinary Tract."

Dr. H. H. McGee, Savannah, Georgia, "Diverticulitis of the Sigmoid with Obstruction."

Dr. Max Mass, Macon, Georgia, "The Use of Acacia Skiodan Mixture in Hysterosalpingography."

Dr. R. C. Pendergrass, Americus, Georgia, "Metastatic Cancer of the Lung."

The following officers of the Georgia Radiological Society were elected for the ensuing year: *President*, Dr. Albert A. Rayle, Atlanta; *Vice-President*, Dr. Harry H. McGee, Savannah; *Secretary-Treasurer*, Dr. Robert Drane, Savannah. Arrangements were made for the mid-winter meeting to be held at Tybee Beach, Georgia.

The Georgia Radiological Society now has 26 members. It holds two meetings a year, one in conjunction with the State Medical Association, the other a mid-winter meeting.

CANCER TEACHING DAY

Two Cancer Teaching Days were held on May 14 and 16 at Johnson City and Forest Hills, New York, under the auspices of various New York State medical societies. At the afternoon and evening meeting at Johnson City on May 14 the following papers were given: Dr. Cushman D. Haagensen, Columbia University, New York, N. Y., "Breast Tumors;" Dr. Gray H. Twombly, Columbia University, New York, N. Y., "Recognition and Treatment of Pelvic Cancer;" Dr. David A. Karnofsky, Sloan-Kettering Institute, New York, N. Y., "Clinical Results from Nitrogen Mustard Therapy;" Dr. Anthony C. Cipollaro, Columbia University, New York, N. Y., "The Diagnosis and Treatment of Cutaneous Cancer and Precancerous Lesions;" Dr. John H. Garlock, Col-

umbia University, New York, N. Y., "Cancer of the Esophagus."

At the meeting at Forest Hills on May 16 the scientific program was as follows: Dr. Leonard Goldman, Queens General Hospital, "A New Method of Teaching Cancer;" Dr. Albert F. R. Andresen, Long Island College of Medicine, Brooklyn, N. Y., "Gastrointestinal Cancer;" Dr. Howard C. Taylor, Jr., Memorial Hospital, New York, N. Y., "Recognition and Treatment of Pelvic Cancer;" Dr. Sture Osterlind, Swedish National Cancer Institute, "Cancer Control in Sweden;" Dr. Maurice Lenz, Columbia University, New York, N. Y., "The Role of Radiation Therapy in the Treatment of Cancer and Allied Diseases;" Dr. Lloyd F. Craver, Cornell University Medical College, New York, N. Y., "Recent Advances in the Treatment of Lymphomas and Leukemias."

ROCKY MOUNTAIN RADIOLOGICAL SOCIETY

The Mid-Summer Conference of the Rocky Mountain Radiological Society will be held at the Shirley Savoy Hotel, Denver, Colorado, August 7, 8 and 9, 1947. The program is not complete but two of the guest speakers will be Dr. Lowell S. Goin, Los Angeles, California, and Dr. Leo G. Rigler, Minneapolis, Minnesota. There will be other guest speakers.

DEPARTMENT OF TECHNIQUE

Department Editor: ROBERT B. TAFT, M.D., B.S., M.A., 103 Rutledge Ave. Charleston, S. C.

FOREIGN BODY LOCALIZATION AND SURGERY

By MAJOR LEON G. BERMAN, MAJOR OTTO D. SAHLER, *and* CAPTAIN ISAAC B. RADOW

MEDICAL CORPS, ARMY OF THE UNITED STATES

IN PERHAPS few other fields of surgery has success been as capricious as in the search for and removal of foreign bodies. This vexing problem has been magnified particularly in time of war, and has disrupted busy operating schedules because of inability to gauge the necessary time for removal of foreign bodies. It will be an even larger problem in post-war and reconstructive surgery. Aside from the obvious externally palpable foreign bodies, there are not many cases which the surgeon approaches with any degree of certainty. Up to the time of the continental invasion, we saw relatively few cases of foreign body requiring removal. In these a lateral and a true anteroposterior roentgenogram were taken, and the surgeon was guided by them. Since operating in France we have found that this method did not always give the surgeon the best approach to the foreign body.

Army directive states that the use of anteroposterior and lateral roentgenograms is still the best method of localizing foreign bodies in a high percentage of cases, with occasional recourse to stereoscopy when available (Circular Letter No. 131, 8 November 1944). However, with our experience disappointing in the past by use of this method (failure in from 30 to 40 per cent of cases), we have recently concentrated on a plan of approach to foreign bodies by use of skin marking under fluoroscopy, employing the bi-plane marker as our guide. Cooperation between x-ray and surgery has been very close, and our recent successful series is without doubt a reflection of the painstaking accuracy of the roentgen department and its liaison with surgery.

In general, the method is applicable only to the head, extremities and parietes of the thorax and abdomen. It will not localize foreign bodies in the cavities of the abdomen or thoras due to movement of the viscera. Extensive wounds do not interfere with marking of the skin as the nearest point of approach usually is located in normal skin away from the wound, and in the occasional case, when necessary, dressings can be taken down in the roentgen department to place a spot in the wound itself. As a rule, planned deliberate removal of foreign bodies which are symptomatic should be the function of rear echelon hospitals, particularly General Hospitals. For this reason the method may not be applicable to forward installations, i.e., Evacuation Hospitals or Field Hospitals, where only easily available foreign bodies are removed incidentally at the time of the primary debridement.

ROENTGENOGRAPHIC TECHNIQUE

Most patients on admission to a General Hospital have satisfactory anteroposterior and lateral views of the area concerned. Additional films are taken when necessary. Our current procedure is to use the regular Army Field Table, with the depth localizer and the Army bi-plane marker. These are standard issue to all General Hospitals, Field Hospitals, Evacuation Hospitals and

750 bed Station Hospitals. Operating instructions for the depth localizer are included in the Army Field X-ray Equipment Instruction Manual accompanying every field x-ray machine (see Fig. 1). Operating instructions for using the bi-plane marker accompany the marker (Item 96191, see Fig. 2).

The patient is placed on the table in a comfortable position arranged so that the foreign body will be as near the upper surface of the body as possible. This relationship is determined either by roentgenograms or by fluoroscopy. The foreign body is then localized in depth, and the skin is marked with either gentian-violet or an indelible pencil. The calculated depth is written on the skin with an indelible pencil. In measuring the skin-screen distance, care should be taken that the depth marker does not press in on the skin. This can be avoided by having a technician observe the marker from the side with a flashlight covered with red paper. If the foreign body is large, an outline of it is made on the skin over the site. The second mark is placed on the skin with the bi-plane marker at exactly 90° to the first mark. At this time it is important to make sure that the spirit levels are correct. The reading obtained on the horizontal tape of the bi-plane marker is then written on the skin near the second mark. At times this may be difficult due to the configuration of the body, particularly true in the gluteal area, but in these cases a

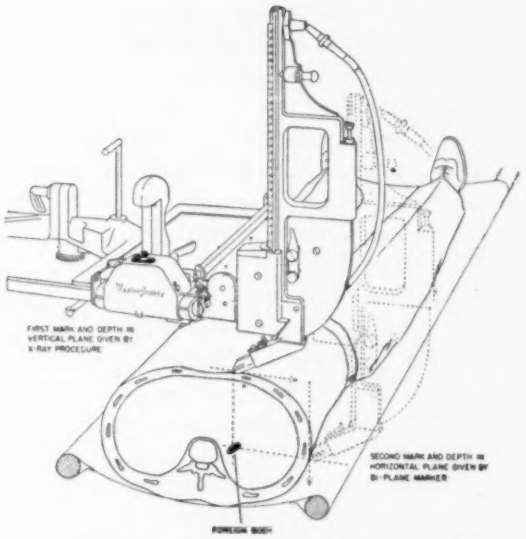
FIRST MARK AND DEPTH IN VERTICAL PLANE GIVEN BY X-RAY PROCEDURE
SECOND MARK AND DEPTH IN HORIZONTAL PLANE GIVEN BY BI-PLANE MARKER
FOREIGN BODY

Fig. 1. United States Army X-ray Field Table Unit Bi-Plane Marker and Re-orienting Device, Manu, al, page 28, Fig. 22. (Reproduced by permission.-)

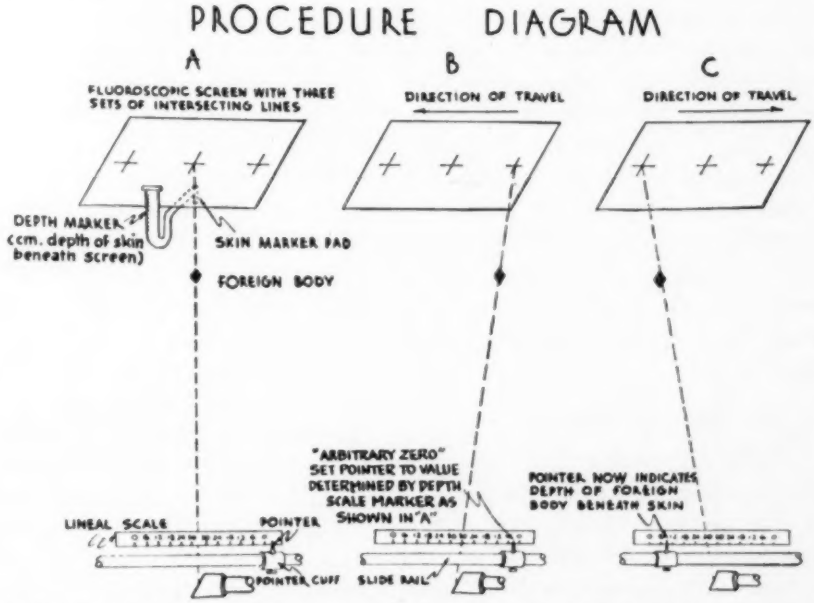

Fig. 2. From the United States Army Field X-Ray Equipment Instruction Manual, page 247. (Reproduced by permission.)

mark is placed on the lateral aspect of the thigh so that the surgeon will always have two marks for orientation. So far we have not used the re-orienting device, primarily because of the difficulty in sterilizing it.

It is important that the depth localizer be very accurately calibrated, and that the screws of the adjustable reading level on the fluoroscopic screen, and the fluoroscopic screen adjustment be locked tightly, so that there will be no change in the calibration. This does not mean that one of the roentgen machines is tied up, for the machine can be used for roentgenography so long as the adjustments on the fluoroscopic screen-arm are not changed. *The localization must be done carefully and the marking placed accurately.* The bi-plane marker can be removed from the fluoroscopic screen between cases and attached only when the second mark is to be made. In this way the bi-plane marker is not in the way of the operator.

It is our impression that a great many roentgenologists have not used the marker, but we feel that it is a great aid and that it does not require much time or skill. In fact any well trained technician can carry out the entire procedure without the assistance of the roentgenologist. However, because of its importance to the surgeon, it is best to have the roentgenologist do the actual localization as it is not time-consuming. The average time is at most five minutes, and after experience it can be done in less time. If these cases are grouped the roentgenologist can keep his eyes accommodated to darkness and have his assistant place the second mark with the bi-plane marker, or do this part of the procedure under red light of a low intensity.

SURGICAL APPROACH

It is extremely important that the parts of the body be positioned as on the fluoroscopy table (the method loses its value unless this is carefully observed). All recent cases, with few exceptions, have been done under local infiltration anesthesia, blocking skin and deep tissues in an ellipse surrounding the skin mark. The mark nearest the foreign body, by actual measurement in centimeters, is chosen for the center of the incision, and a long spinal needle is inserted to the stated depth in centimeters (as determined by the localizer) perpendicular to the horizontal plane. An adequate incision is made with the needle in its center, and tissues are dissected in anatomical planes incising skin, subcutaneous fat and fascia, and bluntly separating muscle fibers along their length. The incision is deepened directly to the point of the guide needle where, with little difficulty, the cavity or nodule containing the foreign body is located. Sulf-penicillin powder is deposited at the site and, where gross purulent material is present, a narrow rubber dam is laid in the tract before the wound is closed. Secondary closure of coincident wounds is done at the same sitting.

During the months of December, 1944, and January, February and March, 1945, 93 foreign bodies were removed using the above method for localization. These were distributed as follows: thigh, 20; leg, 15; arm, 13; axilla, 1; forearm, 2; hand, 11; gluteal region, 6; lumbar muscles, 9; abdominal wall, 2; chest wall, 5; knee, 3; ankle, 1; foot, 1; neck, 4. Seventy-seven of these cases were done in January, February and March, when the study was first undertaken, without a failure. These were performed by the various members of the surgical staff with equal facility, using the technique as outlined, and with sole reliance on the accuracy of the skin marks for placing the incision. Operating time has been markedly reduced and traumatization of tissues has been kept at a minimum, as one would anticipate from a planned, precise procedure as against an approximate incision with probing. Whereas the time for localization in the roentgen department with this method is usually only five to ten minutes, the time saved the surgeon is from one-half to one hour per case, with the added consideration of a more certain prospect of recovery of the foreign body. It is to be understood that only a fraction of the

foreign bodies we have seen have been scheduled for removal, the cases being evaluated on their relationship to function, pain and wound healing; the latter indication presented, of course, in many of the wounds requiring secondary closure.

SUMMARY AND CONCLUSIONS

1. The usual anteroposterior and lateral views have not been found satisfactory by the surgeon in the operating room in recovery of foreign bodies in roughly 30 to 40 per cent of cases.

2. Use of the bi-plane marker (Item 96191) has proved to be an invaluable adjunct in these cases.

3. By use of this method 93 foreign bodies have been removed consecutively without failure, with reduction of operating time one-third to one-half.

4. Success in its use depends upon careful, accurate measurement and marking in the roentgen department, and proper surgical-roentgen ray coordination.

5. The recovery of foreign bodies has become more certain, less time consuming and less traumatizing to tissues.

6. It is recommended that the method be considered as an adjunct in a planned program for localization and removal of foreign bodies, particularly in General Hospitals.

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ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN DIAGNOSIS

HEAD

Lieberman, Alfred T. Aero-otitis media in pressure chamber "flights." *Arch. Otolaryng.*, May, 1946, *43*, 500–507.

Observations were made on the incidence of aero-otitis media in 167 subjects participating in 330 "high altitude flights" in a pressure chamber.

The incidence of symptoms plus objective otoscopic findings of aero-otitis media was 16.6 per cent, while the total incidence of objective otoscopic findings in the tympanic membrane and the middle ear was 27.9 per cent.

Observations in three types of "chamber flights" indicate that low temperature does not increase the incidence of aero-otitis media but that rate of descent and altitude attained are important factors.

A higher incidence of aero-otitis media was observed in subjects with obstruction of the eustachian tubes due to hypertrophied lymphoid tissue than in those with normal-looking ostiums.

The incidence of aero-otitis media was no greater in subjects with subacute infections of the upper respiratory tract than in subjects with no signs or symptoms of infection of the upper respiratory tract.

In this study the incidence of aero-otitis media was about the same in experience.

Observations on 46 subjects showed that in the majority the symptoms of aero-otitis media appeared at about 16,000 feet.—*Mary Frances Vastine.*

Weaver, D. F. Keloid formation in both ear lobes. *Arch. Otolaryng.*, Aug., 1946, *44*, 212–213.

The tendency of the skin of Negroes to form keloids following wounds is well known. This case is reported because (1) it shows the formation of rather large recurring keloids following the simple procedure of piercing the ear lobes for the insertion of ear rings, and (2) recurrence was apparently prevented by the use of roentgen rays.

The factors used in administering the roentgen therapy were: field size, 2 by 4 cm.; kilovolts, 150; filtration, 0.25 mm. copper and 1 mm. aluminum, and focal skin distance, 50 cm. The total dose was 195 r (measured in air).—*Mary Frances Vastine.*

Wright, R. Wesley, and Boyd, Harold M. E. Aerohematoma of the sinuses. *Arch. Otolaryng.*, April, 1946, *43*, 357–370.

Hematoma of the paranasal sinuses is a relatively new and interesting diagnostic entity which has come to light in the present day accelerated flying program. It is a complication encountered occasionally in obstructive aerosinusitis. Because it is directly related to the latter condition, the authors suggest that the term "aerohematoma" be applied to it.

Frequency. The authors have recorded and studied 12 cases of aerohematoma during the past two years. In 11 of these cases the hematoma occurred during a simulated flight in the low pressure chamber. These were the only cases recorded by the writers in over one hundred thousand such flights; aerohematoma is, therefore, not a frequent finding.

Symptomatology. The outstanding symptom in these cases was pain coming on during actual or simulated flight. Other symptoms noted were soreness over the sinus areas, numbness of the face and teeth, discharge of fresh or old blood from the nose and, in a single case, dizziness.

Generally speaking, there was a rather definite relationship between the site of the hematoma and the symptoms experienced by the patient. This might seem to be an obvious finding. However, a correlation of this sort was not always noted in cases of aerosinusitis without hematoma formation. When the hematoma was in the antrum there was either pain or numbness or both over the affected area. On the other hand, in many cases of aerosinusitis observed the pain was felt over the frontal sinus although the pathologic site was found in the antrum on the same side.

Etiologic Factors. Predisposing factors—in 8 of the 12 cases there was a history of a slight cold or of sinusitis at the time of the flight. After

examining the nose and the throat in each case, the authors had the impression that often relatively little that was pathologic could be found to account for the sudden blockage of the ostium of the sinus.

Mechanism of production—More or less rapid changes in atmospheric pressure are necessary for the production of hematoma. In all except 1 case the symptoms developed on descent. Furthermore, the rapidity of descent seems to be the important factor rather than the altitude.

Roentgen Appearance of the Hematoma. Usually a well defined round shadow is present. Later the entire sinus may become cloudy, probably from accompanying reaction to the blood, and then the discrete shadow is no longer visible. At this time the appearance is indistinguishable from sinusitis of any sort.—*Mary Frances Vastine.*

SKELETAL SYSTEM

HEYMAN, CLARENCE H. Spontaneous bilateral fracture of the neck of the femur following irradiation. *J. Bone & Joint Surg.*, Oct., 1945, *27*, 674–678.

Heyman reports a case of bilateral fracture of the neck of the femur following radium and roentgen treatment for a partially differentiated squamous cell carcinoma of the cervix. The treatments consisted of 5,076 milligrams and millicurie-hours, 2,700 hours being given to the uterine canal and 2,376 to the cervix. Daily roentgen treatments were given from July 6 to August 10, 1942, consisting of 2,200 roentgens, measured in air, to each of six pelvic fields (four lower abdominal and two lateral fields), delivering 3,432 tissue roentgens to the center of the pelvis. Two hundred kilovolts and a Thoraeus filter were used at a distance of 70 cm. to fields 15 by 10 cm.

This case, the author believes, typifies the features of spontaneous fracture of the neck of the femur following irradiation. Symptoms did not occur in one hip until fourteen months after the completion of irradiation and in the other hip until eighteen months afterward. Pain was present in each hip at least four weeks before roentgenographic changes were demonstrable. It did not seem likely, in the face of negative roentgenograms during the early period of disabling symptoms, that fracture was the determining cause of pain. The patient, however, was promptly relieved of pain following fixation by means of a nail. Sufficient time has not yet elapsed to predict the end result regarding later degenerative changes of the head of the femur. Bony union is, however, progressing normally as well as can be ascertained. Since it is said that non-union is the rule in this type of fracture, Heyman emphasizes the importance of treatment as prompt and efficient as in other types of fracture of the neck of the femur.—*R. S. Bromer.*

SARPYENER, MÜNIR AHMED. Congenital stricture of the spinal canal. *J. Bone & Joint Surg.*, Jan., 1945, *27*, 70–79.

In 10 patients with spastic diplegia, similar to that found in Little's disease, the author found that lipiodol after injection of the spinal canal was blocked and at laminectomy narrowing of the spinal canal was demonstrated. From the study of his series of cases, he regards the congenital stricture or narrowing of the canal as responsible for many cases of enuresis, clubfoot and spastic and flaccid paralysis leading to abnormalities of gait and contracture. The narrowing of the bony canal compresses the cord. He believes it is also probable that there are congenital strictures of the intervertebral foramina which can cause pressure against the nerve roots. These lesions, unlike those in later life, do not cause pain, since they develop very slowly and tend to inhibit growth of the nerve, whereas the inflammatory constrictions of later life cause sudden pressure against a fully developed nerve and are therefore painful.

The laminectomy should include the narrow vertebrae and the one just distal to it. In cases of spastic diplegia, five or six vertebrae should be included.—*R. S. Bromer.*

KAPLAN, I. I. Vertebral hemangioma in children. *J. Pediat.*, April, 1946, *28*, 498–502.

Vertebral hemangioma in children are usually accompanied by pain in the back and eventually by functional disturbances of the limbs. Blackford has reported an incidence of 10 per cent of bone hemangioma in a large series of routine autopsies. The roentgen appearance consists of coarse vertical striations which may involve the pedicles. There is no decrease in the height of the affected body and no loss of the interspaces. Symptoms when present are due to cord pressure. Irradiation should effect a cure if the lesion is detected and treated before irreparable damage to the cord has occurred.

The author reports a case occurring in a twelve year old boy who was admitted to the hospital complaining of weakness, numbness and some loss of function in the legs. Roentgenograms at the time were suggestive of hemangioma but a diagnosis of spinal neoplasm was made and a laminectomy performed. The pathological diagnosis was hemangioma. Deep roentgen therapy with a filter of 0.5 mm. of copper was instituted and 2,000 r (in air) given to the affected area in a period of two weeks. Slight improvement resulted. In two months a second course of 2,000 r was given and definite improvement resulted. Two more series of 660 r and 1,500 r were given and resulted in practically complete disappearance of the patient's signs and symptoms. At this time there was very little change in the roentgen appearance of the spine. A final series of 1,000 r was given eighteen months after the original course.—*R. M. Harvey.*

Morton, H. S., and Crysler, W. E. Osteochondritis dissecans of the supratrochlear septum. *J. Bone & Joint Surg.*, Jan., 1945, *27*, 12–24.

The authors report 6 cases of osteochondritis dissecans arising from a location at the lower end of the humerus, a specific lesion not previously described. The supratrochlear septum of the humerus, when present, is a thin lamina of bone, separating the coronoid from the olecranon fossa. It varies in thickness from 0.5 mm. to 1 cm. Anteriorly the coronoid fossa is entirely within the elbow joint; while posteriorly, the synovial reflection passes across the upper portion of the floor of the olecranon fossa, so that only the lower half or two-thirds lies within the elbow joint. According to Hirsh, the septum is always present until the age of seven years after which the bony plate occasionally becomes absorbed to form the supratrochlear foramen. When the elbow is flexed completely, the coronoid process fits into the coronoid fossa of the humerus, while in full extension the olecranon process impinges on the floor of the olecranon fossa. In the extremes of movement of this joint, there is apt to be repeated trauma to the septum, which may lead to osteochondritis dissecans.

Osteochondritis dissecans is a non-infectious aseptic necrosis of a segment of subchondral bone, affecting principally the long bones of the extremities, and resulting in an osteocartilaginous sequestrum which may lie free as a free body in the joint. The necrosis appears to be due to interference with the vascular supply and trauma seems to be the chief etiological agent. The microscopic picture is one of necrosis with low grade, productive, aseptic inflammation. Foreign body giant cells are present. Roentgenographic examination is recognized as the principal method of diagnosis.

The 6 cases reported all showed the same lesion. Depending upon the degree of separation, a sharply demarcated, circular or oval button of bone, was seen. If undisplaced, it possessed normal density and was located in the intra-articular portion of the supratrochlear septum. The lateral projection demonstrated the thickness of the ossicle but the frontal projection showed it to best advantage. When separation had occurred, partial or complete extrusion of the ossicle into the humero-ulnar joint occurred, either forward into the coronoid fossa, or backward into the olecranon fossa, thus producing a loose body in the joint.

In all of the cases which came to operation, the histopathological findings were those of osteochondritis dissecans. The clinical manifestations did not differ from those seen in osteochondritis dissecans in other sites. An accessory ossicle of the olecranon process may be confused with this condition in the frontal view as it is projected through the superimposed supratrochlear septum or foramen.—*R. S. Bromer.*

Turkell, Jacob H. Multiple osteochondral bodies in the synovial membrane of the knee joints in a case of mixed rheumatoid and degenerative arthritis. *J. Bone & Joint Surg.*, Jan., 1945, *27*, 149–154.

Multiple osteocartilaginous bodies of joints occur in greatest number in osteochondomatosis. They may also be of articular origin, as detached marginal osteophytes in degenerative arthritis, in neurotrophic joints, in osteochondral fractures of joint surfaces, and in osteochondritis dissecans. Turkell reports a case, diagnosed as mixed rheumatoid and degenerative arthritis, in which multiple cartilaginous bodies were found embedded in the synovial membrane of both knees. He regards the finding of osteochondral bodies in the synovial membrane of the knees, to such an extent as to simulate osteochondromatosis, as an unusual feature when occurring in joints which are the seat of rheumatoid and degenerative changes.

Secondary neurotrophic derangement super-

imposed upon a chronic long-standing rheumatoid and degenerative arthritis was ruled out by negative blood and spinal fluid Wassermann reactions. The involvement of both knees, the histopathological evidence of a chronic synovitis, and the absence of nests of embryonal cartilage in various stages of transformation to the more mature type, tended to indicate an inflammatory rather than a neoplastic or developmental process. He thinks it likely that the bodies arose from peripheral osteophytes which became detached then secondarily embedded in the synovial membrane, or there is also the possibility that the bodies may have arisen by direct metaplasia of the chronic granulation tissue.—*R. S. Bromer.*

McGAW, W. H., and WECKESSER, E. C. Pneumarthrograms of the knee. *J. Bone & Joint Surg.*, July, 1945, *27*, 432–445.

The authors describe a satisfactory procedure for oxygen pneumo-arthrography of the knee which they used in 508 examinations. The technique of the inflation of the joint is given in detail. The joint space is marked on the skin with ink or pencil and the patient is placed in the prone position before being taken to the roentgen department. They have not found it necessary to localize the joint space fluoroscopically. The joint space is spread by a method also described fully in the article and exposures are made with a fine focus tube fitted with a cylindrical cone, 8 cm. in diameter. Five exposures are made as follows: (1) posteroanterior view with spread of the medial joint space; (2) posteroanterior view with spread of the lateral joint space; (3) lateral view with the knee slightly flexed; (4) anteroposterior view with the spread of the medial joint space; (5) anteroposterior view with spread of the lateral joint space.

The following list indicates the types of abnormalities which may be recognized in acceptable roentgenograms:

Many fractures, tears and dislocations of the menisci are clearly shown by abnormal shadows such as irregularity in contour of either femoral or tibial surfaces which suggest tears or shredding; blunting or shortening of the sharp edge indicative of small tears or lesions of the cornu which distort the center of the meniscal shadow; body or basal shadows (in the absence of emphysema) indicative of tears without displacement; partial or complete absence of the meniscal shadow, always indicative either of a dislocation or a previous surgical removal; abnormal size of meniscal shadows such as either too long or too broad, the latter being due to cystic changes in the menisci.

Changes in the suprapatellar bursa, the infrapatellar bursa, the two posterior pouches and the popliteal bursae may also be demonstrated.

Unusual sclerosis of the patella, slight irregularity, and cupping of the articular surface are usually associated with varying degrees of chondrosis.

Laxity of the collateral ligaments is indicated by the amount of separation of the femoral and tibial condyles as seen in posteroanterior and anteroposterior views.

The cruciate ligaments may sometimes be demonstrated on both anteroposterior and lateral views, but rupture cannot be diagnosed roentgenographically by this method.

In conclusion, the authors state that roentgenographic diagnosis of the following internal derangements of the knee joint can be made: many lesions and anomalies of the medial and lateral menisci; cysts of the popliteal space which communicate with the knee joint; a few lesions of the infrapatellar fat pad; some soft tissue tumors of the synovial membrane; some large loose bodies; relaxation of the collateral ligaments.—*R. S. Bromer.*

BERRIDGE, F. R., and BONNIN, J. G. The radiographic examination of the ankle joint including arthrography. *Surg., Gynec. & Obst.*, Oct., 1944, *79*, 383–389.

The roentgenographic examination of any joint is too often thought to be complete when clear outlines of its constituent bones are produced on a roentgen film. It is clinically certain that ligamentous damage is as serious as bony injury and as roentgenologically certain that further amplification of roentgen technique can demonstrate ligamentous injury.

For accurate roentgenography of the ankle the authors employ, supplementary to the usual views: (1) Plain roentgenography in a standard position, compared with a similar film of the opposite side, for investigation of the syndesmosis. (2) Roentgenography under strain (sometimes described as roentgenography in the "position of deformity"). The joint is roentgenographed under a strain appropriate to the ligaments being investigated and supplemented by comparable pictures of the opposite ankle, under similar strain. (3) Arthrography—with a diodone compound. Of these methods roent-

genography under strain gives the most valuable information, and to obtain comparable films of both ankles, pentothal anesthesia is employed in preference to local anesthesia.

Positioning. For accurate roentgenography the knee is placed in the true anteroposterior position and the leg rotated to obtain the desired position. The four positions used are as follows:

1. Anteroposterior, 10 degrees internal rotation. This position is useful in arthrography for showing leakages around the malleoli and extensions upward along the shafts of the tibia and fibula and downward into the peroneal tendon sheaths.

2. Anteroposterior, 30 degrees internal rotation. Films are taken of both ankles in this position as it is the optimum projection to show the width of the tibiofibular syndesmosis. The foot is dorsiflexed. In arthrography, this position shows extensions of the medium into the tibiofibular joint and escape of the medium in cases of rupture of the ligaments of the syndesmosis.

3. A lateral or medial projection with the central ray passing through both malleoli so that they are superimposed (bimalleolar view). This is the best position for showing extensions of the joint cavity anteriorly and posteriorly. The subtaloid joint is very well shown.

4. Lateral with the ankle rotated to throw the fibula behind the tibia (lateral view). This position in some cases shows the extension into the tibiofibular joint better than position 2 and is useful in cases of fracture of the posterior tubercle of the tibia.

Roentgenography under Strain. The fact that 4 to 5 per cent of normal people show a relaxation of the fibular collateral ligament, allowing rotation of the talus of both ankles on inversion of the foot renders comparable films of both ankles necessary when the position of inversion is used. The authors have found no similar ligamentous relaxations occurring normally which affect the other positions of strain.

The varieties of strain used and cases for which they are of value may be summarized:

1. Inversion (tibial flexion) of the hind foot. This is used in cases of suspected damage to the fibular collateral ligament and its most frequently injured fasciculus, the calcaneofibular band.

2. Eversion.—This is used for suspected rupture of the deltoid ligament.

3. Plantar flexion.—In hyperextension injuries the anterior fasciculi of both collateral ligaments may be torn. This lesion is a common cause of bimalleolar signs of sprain with a negative roentgenogram. The bimalleolar roentgenogram is used.

4. External rotation of the foot.—This is used in cases of doubtful diastasis and results in opening up the syndesmosis. The anteroposterior view in 30 degrees of inversion is used.

The essential importance of this method (roentgenography under strain) is the distinction between the sprains and complete ligamentous rupture.

Arthrography of the Ankle Joint. In the authors' experience, more useful information is gained by roentgenography of the joint under strain than by arthrography.

Technique.—As a contrast medium "pyelosil" brand of diodone was used. The amount used was 3 cc. which was increased to 6 cc. in some cases with marked effusions of blood into the joint.

The normal arthrograph.—The joint space shows as a thin line between the upper surface of the talus and the lower surface of the tibia. The line extends downward in the anteroposterior view to just below the malleoli. The anterior sac of the synovial membrane extends forward along the articular surface of the talus and slightly beyond. There is a small posterior sac best seen in the bimalleolar view which is frequently notched by the tendon of the flexor hallucis longus.

The abnormal arthrograph:

1. Site of rupture of ligaments. The escape of the contrast medium from the joint around the lower end of the fibula outlines perfectly the shape of the bone and usually runs a short course with parallel, and even borders before expanding into the subcutaneous tissues over the malleolus. This narrow even band represents filling of the space between the torn fibroperiosteal attachments of the ligaments and the bone. A sprain is due to partial separation of the fibroperiosteal attachment of the ligament, which alone can account for the rapid and profuse hemorrhage which accompanies even the minor sprains.

2. Rupture of the capsule of the joint. Arthrography may shed further light on the severity of injury. Thus in first degree external rotation fractures of the fibula the talus and lower fragment of the fibula may rotate backward, thus tearing the anterior capsule of the ankle and finally the anterior fibers of the deltoid ligament.

3. Anatomical communication of the ankle joint with the tendon sheaths of the peroneii, tibialis posterior, and the extensor hallucis longus have been recognized as occurring normally. Their frequent occurrence in ligamentous rupture is well demonstrated by arthrography.

4. Communication between the ankle and the subtaloid joint is also of recognized normal occurrence. It is particularly common in cases of partial or complete rupture of the fibular collateral ligament, or injury to the lower end of the fibula.—*Mary Frances Vastine.*

McMaster, Paul E. Epiphysitis of the ischial tuberosity. *J. Bone & Joint Surg.*, July, 1945, *27*, 493–495.

Failure of bony fusion of the secondary epiphysis of the ischial tuberosity with fragmentation, resulting in painful disability, is a rare occurrence and the author could find no report of such a condition in the literature. His patient was a white male, aged nineteen, complaining of pain in the left buttock and limb. He first experienced the pain when, at the age of fourteen, while running, he jumped down an incline of a few feet and landed on his left foot. He spent almost four months in bed at the time because of the disability. The pain later gradually decreased. A roentgenogram at the time showed a "chip off the left hip bone."

Anteroposterior roentgenograms of the pelvis showed failure of bony fusion of an enlarged and fragmented secondary epiphysis of the left ischial tuberosity. There was also irregularity in outline and density of the apposing bony surfaces and the intervening cartilaginous plate.

There was no indication that the epiphysis was fusing with the diaphysis. The opposite ischium was normal and revealed fusion of its secondary epiphysis. McMaster states that there is no uniformity of opinion as to whether an ununited, fragmented, painful secondary epiphysis should be designated "epiphysitis," "osteochondritis," or "osteochondrosis." There was no evidence, either in the history or examination, of any endocrine disturbance or other epiphyseal lesions. The patient was unaware of any similar bone lesion in members of his family. There was no history of any systemic disease. It appeared the condition was primarily of traumatic origin. Its features were similar to involvement with subsequent failure of bony fusion of the epiphysis of the tibial tubercle. As the secondary epiphysis and associated cartilaginous plate of the ischial tuberosity were involved and since definite pathological changes were present by roentgenographic study, the term epiphysitis was used to describe the condition.—*R. S. Bromer.*

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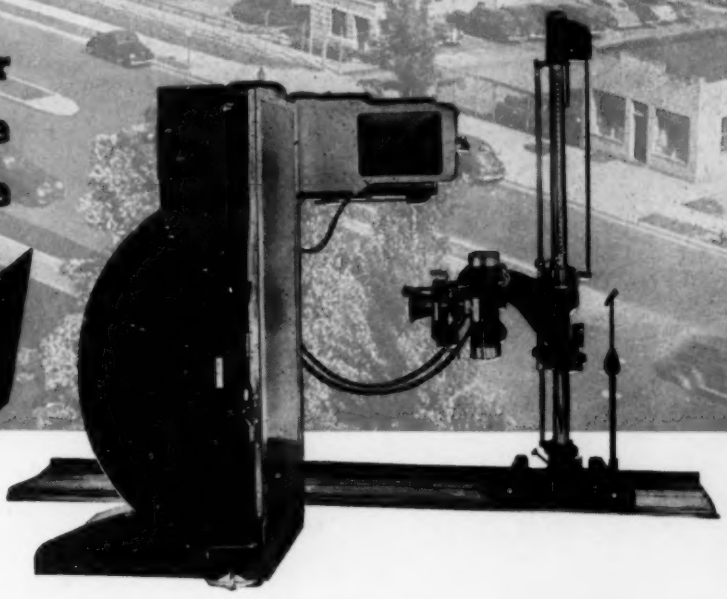

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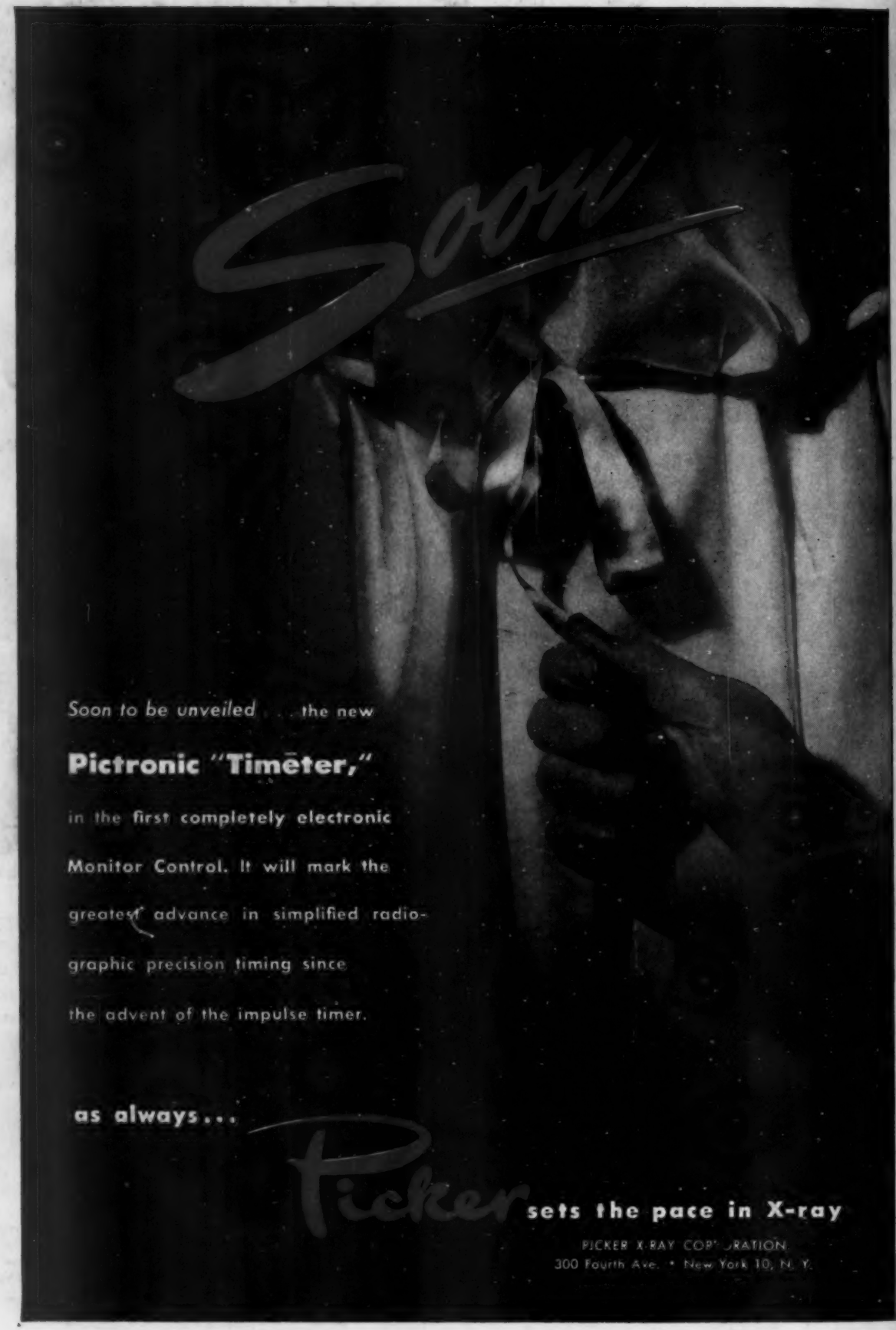

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